ARI Research Note 89-09

An Analysis of Electronic Aids to Maintenance (EAM) for the Light Helicopter Family (LHX)

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for

Contracting Officer's Representative
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January 1989

United States Army
Research Institute for the Behavioral and Social Sciences

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Research accomplished under contract
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Horizons Technology, Inc.

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UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION: Unclassified	1b. RESTRICTIVE MARKINGS: --
2a. SECURITY CLASSIFICATION AUTHORITY: --	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE: --	
4. PERFORMING ORGANIZATION REPORT NUMBER(S): --	5. MONITORING ORGANIZATION REPORT NUMBER(S): ARI Research Note 89-09
6a. NAME OF PERFORMING ORGANIZATION: Horizons Technology, Inc. / 6b. OFFICE SYMBOL (If applicable): --	7a. NAME OF MONITORING ORGANIZATION: U.S. Army Research Institute for the Behavioral and Social Sciences
6c. ADDRESS (City, State, and ZIP Code): 10467 White Granite Drive, Oakton, VA 22124	7b. ADDRESS (City, State, and ZIP Code): 5001 Eisenhower Avenue, Alexandria, VA 22333-5600
8a. NAME OF FUNDING/SPONSORING ORGANIZATION U.S. Same as 7a. / 8b. OFFICE SYMBOL (If applicable): PERI-SM	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: DAA09-85-G-0035
8c. ADDRESS (City, State, and ZIP Code): Same as 7b.	10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
6.37.31	A792	1.2.4	1.2.4.C.1

11. TITLE (Include Security Classification)

An Analysis of Electronic Aids to Maintenance (EAM) for the Light Helicopter Family (LHX)

12. PERSONAL AUTHOR(S)

Frederickson, Edward W., Lindquist, John W., and Lemen, Julie B.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 85/09 TO 87/05	1989, January	82

16. SUPPLEMENTARY NOTATION

John F. Hayes, Contracting Officer's Representative.

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

MANPRINT	ATE	Electronic aids to maintenance
EAM	BIT	Built-in test
LHX	BITE	Built-in test equipment (Continued)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Substantial savings in maintenance manpower and training time, special tools, test equipment, and the storage and handling of repair parts have been predicted for weapons systems that incorporate electronic aids to maintenance (EAM) in their design. Performance deficiencies of weapon system's EAM could have serious consequences to both system availability and MPT (manpower, personnel, and training) requirements. This report provides an overview of contemporary EAM technology. It identifies failures or inadequacies for EAM used in recent weapons systems and projects the results of EAM performance for the Light Helicopter Family (LHX). It also identifies MPT-related solutions relevant to the use of EAM in the LHX program.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION: Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL: Major Charles J. Hintze	22b. TELEPHONE (Include Area Code): (202) 274-8917 / 22c. OFFICE SYMBOL: PERI-SM

DD Form 1473, JUN 86 — Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

UNCLASSIFIED

ARI Research Note 89-09

18. SUBJECT TERMS (Continued)

Automatic test equipment
Light helicopter family

Accesion For	
NTIS CRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and / or Special
A-1	

FOREWORD

The Manned Systems Group of the Army Research Institute for the Behavioral and Social Sciences is concerned with the research, development, and application of MANPRINT (Manpower and Personnel Integration) principles to the acquisition of weapons systems. Substantial savings in maintenance manpower, maintenance training time, special tools, test equipment, and the storage and handling of repair parts have been predicted for weapons systems that incorporate electronic aids to maintenance (EAM) in their design. Performance deficiencies of weapon system's EAM could have serious consequences to both system availability and MPT (manpower, personnel, and training) requirements.

Because the success of EAM is critical to the LHX (Light Helicopter Family) program, the focus of this analysis is on LHX projected performance as it relates to EAM. The findings will be directly useful to the LHX procurement.

This report provides an overview of contemporary EAM technology. It identifies failures or inadequacies for EAM used in recent weapons systems and projects the results of EAM performance for the LHX. It also identifies MPT-related solutions relevant to the use of EAM in the LHX program.

AN ANALYSIS OF ELECTRONIC AIDS TO MAINTENANCE (EAM) FOR THE LIGHT HELICOPTER FAMILY (LHX)

EXECUTIVE SUMMARY

Requirements:

To identify failures or inadequacies for EAM used in recent Department of Defense weapon systems.

To project the results of recent weapon systems EAM failures or inadequacies to estimate EAM performance for the Light Helicopter Family (LHX).

To identify and evaluate manpower, personnel, and training (MPT)-related solutions LHX maintenance organizations can use in coping with EAM failures or inadequacies.

Procedures:

The current project is designed to identify potential problem areas and personnel-related solutions relevant to the use of EAM in the LHX program. To that extent, the research team conducted a review of the literature on the state of the art of EAM technology and military experience with performance of EAM in the field. Following the literature review, the research team obtained EAM performance data on Army systems most comparable to EAM planned for the LHX. The data from these systems were used to develop input values for sensitivity analyses conducted to examine the possible types of BIT/BITE (built-in test/built-in test equipment) failures on mission capability. These analyses were performed using a version of the Administrative and Logistics Down Time (ALDT) model specified in the LHX RAM (Reliability, Availability and Maintainability) Rationale Report. The model was expanded to include operations that involve the use of BIT/BITE. In each of the sensitivities run, one BIT failure type was systematically varied while all other inputs were held constant. Researchers examined the influence of the varied BIT on mission capability. Additionally, one excursion was made in which the probability of all types of BIT failures were input as zero to establish conditions created by perfect BIT.

Findings:

The review of the literature and examination of data obtained on comparable Army systems indicate that BIT/BITE has not

met performance expectations and that BIT/BITE failures have increased down time and increased and complicated maintenance. Furthermore, based on the rate of false alarm detections for four recent Army weapon systems, there has not been a significant advancement of the BIT/BITE technology for reducing false alarm rates. Therefore, technicians must be able to take over the troubleshooting tasks when the BIT/BITE fails. To maintain the desired mission capability may require an increase in maintenance personnel, maintenance training, or both, in order to effect timely repairs when the BIT fails.

It is not within the scope of this effort to identify specific EAM potentials under varying operational and climatic conditions. However, it appears that 90 to 95% coverage of electronic systems to the line replaceable unit (LRU) level with a 95% reliability approaches the limit of reasonable expectations. For other than electronic systems, the technological limit appears to be considerably lower.

A sensitivity analysis was run to determine the impact of changes in the probability of EAM failures and changes in delay times due to evacuation of aircraft to depot. The results indicate that 11 LHX scout/attack helicopters employed in an attack helicopter company to perform two back-to-back three-hour, 8-aircraft missions in each 18-hour cycle for a 7-day period will achieve an availability ranging from 68% for perfect BIT to 59% for BIT with performance equal to the AH-64A. The sensitivity analysis indicates the largest opportunity for improvement (approximately 8 percentage points) lies in the delay times associated with depot maintenance. For every hour of delay that is avoided, there is almost 1% improvement in aircraft availability. The second largest opportunity for improvement lies in the percentage of error associated with false indication of a fault failure mode that accounts for approximately 6 percentage points of aircraft availability. On the other end of the spectrum is the failure mode in which the BIT cannot locate the faulty LRU. Totally eliminating this failure while holding all other parameters constant at the base case value will only achieve a 1.4% improvement in aircraft availability.

Potential manpower, personnel, and training solutions that may compensate for expected EAM performance were examined. Reducing administrative and logistics delays is extremely sensitive to the positioning of maintainers. In the event that there is an EAM failure, the more quickly maintenance repairers can be made available, the shorter the down time. In the case of the LHX, as the delay time awaiting depot maintenance is reduced, aircraft availability is improved by approximately 8%. Possible ways to reduce the time waiting for depot maintenance include the formation of contact teams that deploy rapidly to the defective aircraft, the positioning of highly trained diagnosticians at the

Aviation Maintenance Company or the Aviation Battalion Headquarters and Service Company, or the extreme option of training every repairer to conduct off-line troubleshooting. A combination of actions that involves placing more diagnostic capability at the unit level appears to be the best solution to the problem.

Utilization of Findings:

The modified ALDT model developed in this effort can be used to examine the impact of EAM performance on weapon systems throughout the development process. As more precise information regarding the hardware and software to be employed becomes available, sensitivity analyses can be run to examine the impact of EAM on any given system's operational availability. The results of the analyses conducted in this effort will be provided to the LHX Program Manager as part of a program of ongoing MANPRINT research for the LHX. However, due to the closely guarded nature of the LHX and Advanced Rotorcraft Technology Integration data, the research team was unable to identify specific and detailed solutions to EAM deficiencies. As the data are released, it should be possible to apply the model to the aircraft system and its specific components to conduct tradeoffs between maintenance concepts, manpower, personnel, and training policies, and mission capability.

AN ANALYSIS OF ELECTRONIC AIDS TO MAINTENANCE (EAM) FOR THE LIGHT HELICOPTER FAMILY (LHX)

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INTRODUCTION

Background

The current analysis grew out of a concern on the part of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) that a major problem with respect to the operational availability (A_O) of an emerging weapon system would involve the capabilities and performance of various electronic aids to maintenance (EAM) (e.g., built-in test/built-in test equipment (BIT/BITE), automatic test equipment (ATE), prognostic systems, etc.). Mean times to repair (MTTRs) for various weapon system components (a major factor in system availability planning), and the system's maintenance, logistics support, manpower, personnel and training (MPT) requirements are based upon projections concerning the performance of the various planned EAM systems. Hence, performance deficiencies on the part of the weapon system's EAM could have serious consequences with respect to both system availability and MPT requirements.

ARI's concern regarding the performance of EAM systems is based upon published reports, field observations, and anecdotal information indicating that the operational performance of EAM on current systems often falls considerably short of developmental goals. The reported reasons for the operational inadequacies of EAM range from purely technical to human. Often, for example, automatic fault detection and isolation systems are not exhaustive in their coverage of system malfunctions, but the gaps are not discovered until after users have gained some experience with the system. In other situations, improperly trained or careless maintenance technicians are the reported cause of EAM performance inadequacies. Whatever the cause, operational inadequacies on the part of EAM can lead to a variety of undesirable consequences. These consequences can range from lowered rates of A_O (i.e., unit maintenance personnel can repair their equipment but not as quickly as planned) to a total inability of unit maintenance personnel to maintain their equipment without significant outside assistance.

Objectives

Given the serious nature of the implications of inadequate operational performance of EAM for future weapon systems, the current analysis was chartered with three principal objectives:

1. Identify failures or inadequacies for EAM used in recent Department of Defense weapon systems.

2. Project the results of recent weapon systems EAM failures or inadequacies to estimate EAM performance for the Light Helicopter Family (LHX).

3. Identify and evaluate MPT-related solutions that can be used to aid LHX maintenance organizations in coping with EAM failures or inadequacies.

Scope

Given the early stage of development of the LHX, precise data related to the LHX itself are unavailable. Likewise, the technology used in EAM for the LHX is still under development. For these reasons, the inferences made regarding EAM performance for the LHX are based on the integration of data from predecessor systems with the LHX concepts. Therefore, the conclusions reached in the current analysis should be interpreted as the results of "first-cut" analyses and re-examined as new data, specific to the LHX, become available in the future. Until that time, however, the analyses provide the best available data concerning the likely performance of LHX EAM and the impacts of its performance on operational availability of the LHX.

Methodology

The analysis was conducted in two phases:

1. Research to determine the state-of-the-art of BIT/BITE and the military experience with BIT/BITE;

2. Application of the results of phase one to the LHX.

The first phase consisted of a literature search (see references) and compilation of data on the performance of BIT in selected weapon systems in the military inventory. The literature search was used to compile a brief history of BIT/BITE, to identify the strengths and weaknesses of built-in test equipment, and to determine what might reasonably be expected of BIT as applied in the LHX. Data was compiled on existing systems in order to establish a base-case from which LHX BIT performance could be developed.

The second phase of the analysis consisted of modeling BIT performance in the LHX context (see Appendix B) with the outputs reflecting mission capability. Different levels of BIT performance were analyzed to identify the sensitivity of mission capability to the various failure modes. MPT solutions were then investigated in terms of their ability to affect the more sensitive failure areas.

Organization of the Report

The next section of the report represents an overview of contemporary EAM technology and systems. It provides, in non-technical language, an explanation of the topic so that a

reader can develop a basic understanding of the subject area. The Military Experiences with Electronic Aids in Maintenance section presents a discussion of the military's experience with EAM as well as an analysis of EAM operational performance on predecessor and comparable systems in the Army inventory. Systems on which data were collected for this purpose include the AH-64A and the OH-58D helicopters, and the Patriot air defense missile system. Finally, the EAM for the LHX section addresses the implications of potential EAM performance for the LHX. It provides: (a) an overview of the LHX EAM concept, (b) a discussion of potential operational performance on the part of LHX EAM, (c) an assessment of the potential impact of EAM performance on LHX mission capability, and (d) a discussion of potential MPT adjustments to alleviate BIT induced problems with the proposed maintenance support concept.

ELECTRONIC AIDS TO MAINTENANCE: TECHNOLOGY AND SYSTEMS

EAM Concept and Rationale

This section of the report provides an overview of the EAM concept. For purposes of this report, EAM are defined to mean any instrument, device, component, or software which serves to provide information to operations or maintenance personnel regarding the status of a weapon system including information on system or subsystem failures that have occurred, are occurring, or may occur. The EAM equipment may take a variety of forms. The equipment and software may be an integral part of the weapon system or it may be in the form of instruments or other equipment that are electronically connected to the weapon system to perform the EAM function. Alternatively, the EAM may consist of instruments or testers located in a fixed facility and used to test portions of a weapon system, or even a whole system, which has been removed from its normal field operating environment.

In their most basic form, EAM have been used to support maintenance activities for a considerable period of time--since the earliest days of military electro-mechanical systems. In recent years, however, there has been a shift in the usage concept underlying these maintenance support tools. In the early days of EAM, the concept was one of using status monitoring and test equipment to support the maintenance technician; the maintenance technician remained the key element in the maintenance activity. In recent years, particularly with the increasing availability and application of data processing technology in the maintenance domain, the focus of EAM usage has shifted from the man to the machine (i.e., a maintenance function re-allocation from man to machine). Complex EAM have been developed in which maintenance technicians can almost be thought of as being subordinate to the EAM. Using these systems, fault detection and isolation (the most complex aspects of maintenance) can be carried out, in theory at least, virtually without human intervention.

The objectives underlying the shift in focus from man to machine in an EAM intensive maintenance environment are threefold: (1) to increase operational availability (and thus combat readiness), (2) to save maintenance time, and (3) to reduce maintenance-related personnel costs. Both integral and external test equipment can help to ensure that a weapon system is functioning properly. In the event of a malfunction, it can provide information to the operator to cancel or abort a mission, or to compensate for the malfunction if the mission continues.

Information provided to maintenance personnel, regardless of levels, can enable faster repair and reduce the labor required to effect the repair. In some cases, where the weapon system is extremely complex, timely diagnosis may not be possible without EAM. Furthermore, in the case of highly automated EAM, human intervention may only be required for initial setup of the EAM. Once the initial setup has been accomplished, the test equipment performs the entire diagnosis. Shifting the focus of fault detection and isolation from humans to EAM thus has the effect of: (1) increasing maintenance efficiency (with a corresponding reduction in maintenance manpower requirements), (2) reducing personnel selection criteria (fault isolation is one of the most cognitively demanding aspects of a maintenance technician's job), and (3) reducing maintenance training time and complexity (time devoted to training in diagnostics and fault isolation can be reduced significantly).

All of the features associated with extensive use of EAM are extremely appealing to system designers and procurement decision makers who must develop systems to operate in a resource constrained environment. However, the ability of EAM to provide the benefits described above for future weapon systems is directly related to the state-of-the-art of EAM technology and the performance of such systems in the field. The remainder of this section of the report provides an overview of EAM technology and the performance of existing EAM systems in the military environment.

EAM Technology

Systems designed to perform EAM functions may be classified into two basic categories: built-in test equipment (BITE) and automated test equipment (ATE). The first category, BITE, refers to equipment which is an integral part of the system or connected to the system and carried on-board when the system is operating. The second category, ATE, performs similar functions as BITE but is used during maintenance operations when the system is not involved in mission operations.

The built-in test (BIT) function of EAM involves both hardware and software systems and is the primary focus of the review of EAM technology. BITE refers to the hardware portion of BIT and for the rest of this discussion will be included in the term BIT.

Built-In Test Overview

BIT is incorporated into prime equipment to perform two basic functions, fault detection and fault isolation. The fault detection function includes two tasks, system monitoring and system checkout. The fault isolation function represents a third, distinct task which involves the identification of the particular component or subsystem in which the failure has occurred. The ability of differing BIT designs to perform the three tasks varies with the characteristics of the equipment and criticality of the BIT function.

Fault Detection

System Monitoring. The design of equipment, such as automated navigation systems, whose failure can affect the safety of flight has led to the development of BIT which interacts with and controls the operation of the system. Such equipment usually involves many electronic components which must "communicate" with one another. Data buses provide the communication links between different parts of the system in a similar manner to the way telephone lines provide communication links between telephones. During operation of systems which are interconnected by data buses, there is also a need to continuously monitor equipment on the bus to avoid using erroneous data. This has led to the development of software monitoring of peripheral equipment. When redundant systems are incorporated, it becomes necessary to monitor the active channel and, if inactive, standby redundancy is employed to switch over to the second channel upon failure. Systems, such as warning receivers designed to alert the crew only when selected signals such as threat antiaircraft radar are received, require some form of periodic test to verify system integrity. Both modes of system monitoring, continuous and periodic, have become prime functions of BIT. In both cases the BIT automatically assesses the system. In theory at least, there are no demands put on the operator until the BIT diagnoses a fault.

System Checkout. The second task of BIT in fault detection is to accomplish system checkout prior to operation. During system checkout, the BIT, with possible crew intervention, performs functional checks to ensure that the system is fully operational. This type of check includes checks of the BIT itself.

Fault Isolation

A third and distinct task of BIT is to aid the maintenance crew in isolating faults to the failed subsystem, component, or line replaceable unit (LRU). This function of BIT is the most complicated and may be the one which is the most important in terms of cost, manpower, personnel and training. To be effective, BIT must correctly detect a system malfunction, and then correctly isolate the cause to the failed component.

BIT Characteristics and Description

There are several types of BIT which may be categorized by function. The three principal types of BIT include comparison monitors, wraparounds, and signal monitors.

In the comparison monitor, signals from two nearly identical channels are compared at the point of signal output, and, if a difference is detected, a fault is indicated. An example of this type of BIT is in equipment which generates frequencies; such as communications equipment. The frequency is compared to a frequency generated internally to the BIT. If the system frequency is too high or too low, it is reported as faulty. This is true even if the BIT is out of calibration and tries to compare the correct system signal with its incorrect signal.

Wraparound BIT operates by injecting a signal through the equipment under test and monitoring the same signal at the output. If a signal other than the one expected is output, then, the BIT indicates that a fault exists. This form of BIT is most often utilized in complicated digital circuit; such as information processors.

The signal monitor implementation of BIT, monitors the level of certain signals. A signal that exceeds the limits of the level is reported as faulty. An example of this type of BIT is the temperature gauge on an automobile which will register hot when the temperature exceeds a certain limit.

There are two basic ways to activate BIT; automatically by the system in normal operation, or on demand by the maintainer or operator in pre- and post-operation system checks. In normal operation of the system, BIT primarily tests mission critical and flight critical functions like the navigation system.

BIT Failure Modes

BIT failures fall into three basic categories each of which have the potential to interfere with or adversely affect the availability of the mission system. The categories and their effects follow.

Induced Failures

Induced failures are faults in the host or object system that are caused by a malfunction or failure of the BIT. That is, th BIT malfunctions in such a way that it causes damage to or interferes with the proper functioning of the host system. If the BIT is fully integrated with the host system and therefore shares circuitry, the opportunity for induced failures to occur increases. At the same time, integration makes identification of cause and effect with respect to the BIT more difficult. Induced

failures decrease the available time of the mission system because if the BIT did not exist, the failure and its associated not mission capable maintenance or supply status would not have occurred.

False Indications

False indications are either an indication of a fault when none exists or the failure to indicate a fault when one does exist.

The first type, false indication of a fault, is identified by an inability to duplicate the fault during a retest. Therefore, they are often called "could not duplicate" (CND) faults or "false alarms". However, not all CNDs are false indications. CND faults are also caused by intermittent failures or a weakened condition. They are often warnings of a hard failure and if recognized as such, can greatly aid the maintenance process. Until a hard failure occurs, however, it is extremely difficult to isolate the problem.

Although a false indication of a fault does not actually change the condition of the mission system, the operator has no choice except to behave as if the report is true until further testing proves otherwise. Until such testing, which can range from a few seconds for a recycle of the BIT to several hours for complex off-system diagnostics, is completed, the system is not available.

In the second type, false indication of a ready condition, the BIT does not indicate a failure when the system has a valid failure. Failure to report faults occurs most often in circuits which have multiple faults and not all of them are identified. The implications of a failure to report a faulty condition are: (1) continued operation may cause a catastrophic failure resulting in the total loss of the system, or (2) further damage may occur resulting in increased maintenance time or a mission failure if the fault is not discovered until an attempt is made to use the system. If the mission is time sensitive, it may not be possible to employ another mission system. Whereas, if the fault had been identified earlier by the BIT, planning changes may have avoided an actual mission failure.

Isolation Error

Isolation error occurs when BIT detects a fault but, when operated in the maintenance troubleshooting mode, isolates the cause of the fault to the wrong component or LRU. Incorrect reporting of faults occurs during the fault isolation or diagnostic process. It happens most often in circuits that are spread over several circuit boards. BIT can easily identify failures and locate them to a general circuit, but has difficulty

isolating the fault to an exact location. Consequently, the wrong circuit board is reported as faulty or the BIT is unable to complete the diagnostic. All of these instances cause downtime of the system and necessitate the presence of maintenance personnel. A false isolation impacts availability by directly increasing the maintenance time. First the component which was falsely identified as failed must be repaired or replaced. Subsequent to the repair, it will be noted that the original fault in the mission system still exists thus necessitating alternative troubleshooting procedures and repair of the component that has actually failed.

Automatic Test Equipment

In those cases where there is no BIT, or the BIT fails, the next diagnostic option is to use automatic test equipment (ATE). ATE is separate, external test equipment that contains circuitry very similar to BIT and which performs diagnosis of otherwise identified faults in much the same manner as BIT.

Test Sets

In the absence of both BIT and ATE, test sets are the next available diagnostic tool. Test sets are stand alone pieces of diagnostic equipment. They are used to diagnose limited components such as line replaceable units, or shop replaceable units, or to diagnose limited functions such as the continuity of a line, an output voltage or a mechanical function such as rotor blade tracking.

Limitations of Current EAM Technology and Systems

EAM technology has several important limitations related to the state-of-the-art of technology and to the nature of BIT itself. Today's equipment systems usually consist of several smaller subsystems, which are all somewhat unique. Due to the differences in these subsystems, the faults occurring within an overall system are not normally distributed. Typically, 20% of a system will be the source of 80% of the faults (NPRDC, 1985, p. 3). Efforts to develop on-board BIT for the entire system would be cost prohibitive, even if it were possible. The limitations include:

- On-line background operation,
- Limited hardware real estate (room on board), software memory and computing time,
- Isolation capabilities.

BIT operates on-line to detect failures and to monitor system status, and operates off-line to isolate failures. Operating on-line requires BIT to function in the background so it will not interfere with normal operation of the subsystem under test. In normal operation, or if BIT experiences a malfunction, its operation should not affect the system operation in any way. However, since the BIT must be connected directly to the circuitry of the host system, it is not possible to eliminate totally BIT induced malfunctions in the host system. The requirement to be non-interfering limits the types of tests that may be performed by BIT.

There are often a few subsystems that have a very low failure rate but are extremely important in function. Such a subsystem is the identification, friend or foe (IFF) for the Patriot air defense system. One failure in the IFF not detected by BIT could have catastrophic results; such as, engaging a friendly aircraft. The end result is the need for extremely reliable and extensive BIT in a subsystem which contributes less than one percent of the failure rate. A few subsystems like the IFF could consume a large portion of the available hardware real estate, software memory, or computing time.

BIT is also limited in its isolation capabilities. Unless an interface is provided, mechanical systems cannot be accessed. As a simplistic example, consider the engine of an automobile. To monitor the temperature, a temperature sensor is placed in the engine and attached by a cable to a gauge that displays the current temperature of the engine. To monitor the air pressure in the tires is not so simple. For some subsystems it is more practical to use some form of external test equipment, in this case a tire gauge. Electro-mechanical systems often have sensors providing information to BIT, on which BIT must rely. The maintainer will have to fault isolate those systems not tested by BIT using off-board ATE.

Circuits which are spread out over several circuit boards pose a difficult problem to BIT isolation. BIT can detect which circuit is faulty and even which area, but if that part of the circuit is located on several different circuit boards, BIT cannot determine which circuit board has the faulty component. This adds to the false isolation errors committed by BIT. To avoid this problem, circuits should be contained on as few circuit boards as possible.

Automatic test equipment is not hampered by the same limitations as BIT. Although ATE is limited to a reasonable size, the entire equipment is dedicated to test and evaluation, eliminating the need to share computer time with the host system allowing it to perform more thorough tests.

The major limitation of ATE is the interface between it and the subsystem under test. In a typical set up, several test leads and test probes will be connected from the ATE to test

points on the subsystem. These test points must be easily accessible to the ATE and also provide pertinent information about the subsystem under test. If provisions have not been made during the design of the subsystem for pertinent test points, the ATE may not be able to fault isolate the subsystem accurately.

Many of the limitations for both BIT and ATE can be avoided in the design of the overall system. Alternate methods of monitoring subsystems can be found for BIT to monitor and fault detect on-line systems adequately. Fault isolation can be accomplished for the system using both BIT and ATE. The maintainer will have to be involved for a small percentage of fault isolation, but this small percentage is typically the most difficult to isolate.

Future Directions of EAM Technology and Systems

There are several new areas of technology which will greatly affect EAM. These areas include artificial intelligence, prognostics, very high speed integrated circuits, and automated maintenance manuals.

Artificial Intelligence

Artificial Intelligence (AI) technology is intended to design and produce "intelligent" computers that can imitate the human thought process, yet attain more accurate results. AI is defined as the application of knowledge, thought and learning to computer systems to aid humans. AI technology has grown significantly over the past several years. The growth has been primarily to extend the application of technology to commercial systems rather than develop new technology. The most significant efforts in AI have been in the area of expert systems and natural language understanding. (Daniels, 1986, p. 21).

The application of AI in electronic aids to maintenance involves the extraction and generation of information in understanding the surrounding environment. This process is referred to as an expert system. Expert systems are computer programs that duplicate to some degree the kind of results achieved by human experts. These systems are able to solve problems, to predict, to provide a rationale and give advice in a narrow area of consideration. The best known expert systems have been developed for medical diagnosis, mineral prospecting, chemical analysis and computer configuration.

The goal in adapting expert systems to maintenance diagnostics is to provide an intelligent maintenance aid to enable the maintainer to reduce the fault isolation time, improve the accuracy of the diagnosis and respond rapidly to changing situations. Maintenance and fault diagnosis are very promising areas for expert systems.

For electronic fault diagnosis, the data base of the expert system should consist of two kinds of information: detailed specifications for the equipment to be diagnosed; and results of measurements. The specifications consist of such information as functional descriptions, interconnections, nominal values for normal operating parameters and component values and tolerances. These kinds of information must be available for each piece of equipment and are equivalent to the manuals and performance specifications maintenance personnel would use. The additional information in the knowledge base consists of symptoms data, results of measurements, general diagnostic methods, rules associated with particular classes of equipment and rules peculiar to the specific equipment being tested.

In operation, the diagnostic expert system examines the knowledge base, looking for rules to apply. In the early stages of diagnosis, the application of rules is primarily for the purpose of making key measurements to be added to the data base. In later steps, many inferences are possible with only limited additional measurements. One objective of using expert systems for diagnosis is to minimize the total testing time by reducing the number of measurements necessary to diagnose the fault. At each step, the expert system looks for a final diagnosis, and where that is not possible with the data available, it determines the next best test to make in order to rule out the most possibilities.

The application of AI to maintenance and fault diagnosis will improve upon the inroads BIT made. The AI maintenance system will be more accurate, more thorough, faster and will be able to test more functions. The amount of manual fault diagnostics will decrease; however, the human maintainer will still be required to override the EAM system if need be and to operate the on-demand fault diagnostics. (Papenhausen, 1986, p. 73).

The military, particularly the avionics community, has demonstrated a high level of commitment to automation. Most of the measurement and stimulus equipment needed for immediate application of expert systems already exists and is designed for computer control. The U.S. Air Force is currently developing the central integrated test expert parameter system (CEPS) which is a maintenance diagnostic system for the B-1B strategic bomber. Boeing Military Airplane Company is the prime contractor for the development. The CEPS will address the B-1Bs offensive avionics system and provide maintenance technicians with improved diagnostic capabilities. The CEPS is an off-aircraft system which assists the technician in assembling and considering all of the information relative to a particular avionics problem. Moreover, it will allow him to make more accurate and timely corrections.

CEPS consists of three major components: a data base, an expert system and a diagnostic tool kit. The data base is a repository of maintenance history, storing up to two years of data on-line. The expert system provides the system's power by

emulating a human expert's reasoning capabilities. The diagnostic tool kit of CEPS consists of a series of aids that provide specific enhancements to the system's overall diagnostic capabilities.

As a maintenance aid, CEPS provides access to an automated analysis of recorded inflight data, which allows it to perform dynamic testing. As CEPS matures, it will provide a diagnostic consultation capability equivalent to many years of maintenance experience. The data base will provide an excellent vehicle for failure analysis and prediction and can serve as the nucleus of a possible preventive maintenance scheduling system. By providing a single, comprehensive source of information about B-1B avionics malfunctions, recorded parametric data and maintenance actions, CEPS will improve maintenance efficiency at all levels.

Prognostics

Prognostics attempt to predict impending failures or malfunctions. This technology is receiving increased attention and is growing rapidly. Performing prognostics requires BIT with a reasonable amount of data recording and processing capability. Prognostics is accomplished as follows: The functioning of a particular unit, such as a sensor or a circuit, is frequently monitored and the observations recorded. As the unit ages, its performance tends to drift away from its design performance. The resulting performance may still be within allowable tolerances. By monitoring these changes, they can be used to predict the occurrence of continual and larger changes leading to a failure or malfunction. The EAM would then warn the operators or maintainers of incipient failures.

Prognostics would allow a higher potential mission effectiveness, with the ability to abort or compensate when a failure is about to occur. It would also help eliminate periodic maintenance that is used to check for the sort of impending failure that the prognostic monitoring is performing. Prognostics is an aid to the maintainer, allowing him to perform maintenance on an "as needed" basis. It also enables him to perform maintenance on equipment which is about to fail without having to wait until a mission is affected. The maintainers' tasks will not be eliminated, just made more efficient.

Very High Speed Integrated Circuits

Very High Speed Integrated Circuits (VHSIC) technology incorporates advanced etching techniques to put more gates on a single chip than ever before. This allows several functions to be placed on a single chip reducing the paths between gates and the power required to drive the signals. Both bipolar and complimentary metal oxide semi-conductor technology are used providing a faster circuit with less power consumption.

VHSIC technology provides faster operating circuits which, when used in digital computers, allows greater computing capability. It also provides significant potential benefits for BIT. Increased speeds for weapon system on-board processors can permit their use for both the weapon data processing and control, and also for BIT processing. BIT can be performed at greater speeds without the need for significant additional equipment, and the associated cost and space. VHSIC will aid the other technological advances but will not have any direct impact on human maintenance functions.

Several companies, including TRW Electronics Systems Group, have developed chip sets which utilize VHSIC technology. These chips can handle a wide variety of high speed sorting, arithmetic, memory, and interconnect functions. VHSIC technology will soon be available for use in production enabling systems designers to incorporate it into EAM.

Automated Maintenance Manuals

Automating a maintenance manual simply means putting the information on a medium which is easily accessed by a computer. The manual can be on a hard disk, a floppy disk or a WORM (write once read mostly) disk. The computer is used to automatically display the appropriate information. It encourages interactive diagnostics with the maintenance personnel increasing the speed and success of repair.

The user is prompted to call up the appropriate manual by the fault detection/location computer. He may then follow the instructions prompted by the maintenance manual. For example, many manuals utilize fault trees to aid the maintainer in debugging the equipment. The same process would occur here except the branching is performed by the computer eliminating errors due to the maintainer accidently branching to the wrong page in the manual. The user is queried and the computer either asks another question or it branches to a new page. The entire process is similar to using a programmed textbook.

The maintainer may also use the maintenance manual as a reference. He would bring the maintenance manual up as before but instead of allowing the computer to step him through the maintenance procedures he would search for the specific item he needs. The search is performed by the computer given a keyword, the name of an equipment item, a task, etc. The search process is performed much like it is on a word processor. If the maintainer is unsure of exactly what he needs, he may scan through the manual a page at a time, a chapter at a time or by any other method he wishes. The automated maintenance manual provides fast access to information and easy cross-referencing.

Summary

EAM technology provides significant opportunity to enhance future weapon system availability through (1) rapid, accurate fault detection, (2) rapid fault isolation, (3) predicting impending failures, and (4) providing quick access to technical information. Judiciously applied, all of the above can enable personnel reductions in terms of both numbers and aptitudes required. However, size, weight, cost, and the need not to interfere with normal system operation may act as limiting factors to the practical application of BIT. These limitations may be mitigated somewhat by the fact that the preponderance of system failures occur in a relatively small percentage of the weapon system.

The next section of this report discusses the experiences to date of the military services with EAM and more specifically military experience with BIT. The intent of the review is to identify recent military weapon systems in which BIT has been applied and assess the performance of BIT for each of these weapon systems.

MILITARY EXPERIENCES WITH ELECTRONIC AIDS IN MAINTENANCE

Introduction

Over the past decade the weapon systems acquired by the Army, Navy, and Air Force have increasingly incorporated more complex state-of-the-art technology. The increase in mission capability enabled by the innovative application of technology to weapon systems has led to the goal of current acquisition programs to go beyond state-of-the-art technology and attempt to include emerging technology in the concept development phase. However, one of the significant costs of technology has been a change in the types of skills required to sustain the operational availability of the weapon system. In short, technology has dramatically increased the complexity of weapon system operation and maintenance. Electronic aids to maintenance, particularly built-in test equipment, have been in the forefront of the battle against skill creep and the associated sub-optimal operational availability of weapon systems.

Although BIT/BITE has made a major contribution to controlling weapon system maintenance time and maintenance training, it has not been an unqualified success. A Defense Science Board panel (1982) found that most attempts to deal with these problems through the use of high performance technical systems have produced several kinds of problems - "shortages of skilled personnel and spare parts, unnecessary maintenance, incompatible test equipment and inflexible maintenance practices" (Defense Science Board, 1982, p. 6). They attribute many of the difficulties to the removal-and-replace philosophy, "which

depends heavily on built-in diagnostic and automatic check-out equipment" (Defense Science Board, 1982, p. 6-8). In using high technology concepts to reduce the complexity of the operator tasks, "the complexity of maintenance tasks has shot up" (Defense Science Board, 1982, p. 6-8). The essence of the findings of the Defense Science Board was that the LRU concept combined with the use of BIT/BITE fault detection/isolation has not worked as desired. The Defense Science Board's panel concluded from their study:

"Concerns relative to the maintainability of equipment with a multiplicity of removable assemblies were quieted with the promise of automatic fault detection and isolation capabilities that stretched into the high ninety percentile range. While these promises looked good on paper and were incorporated in almost all specifications, the actual field performance has been nothing short of a disaster" (Defense Science Board, May 1982, p. 6-10).

Two new maintenance problems have come about as a result of the use of automatic fault detection and isolation equipment and the relatively poor performance of such equipment. First, the diagnostic equipment in many cases has turned out to be as complicated to operate and maintain as the prime system equipment itself. For example, Spinney (1981) has reported that the automatic test station used with the Air Force's F-15 aircraft contains 220,000 parts that have to be fault isolated and replaced when they fail. That is more than twice the number of electronic parts in the F-15. There are over 280 different technical orders and 100 different computer programs on 530 reels of tape for use in troubleshooting the avionics subsystems. The hookup of the station requires up to 85 interface connections.

The second new maintenance problem is one created by the failure of the automated diagnostic equipment to detect and correctly isolate faults (high false alarm rates have been found to be the norm). When the automatic diagnostics do not work, manual techniques must be used, "which in turn requires that the technician know how the system is integrated, what functions are performed in what boxes and how a failure in a particular box affects the system" (Carpenter-Huffman & Rostker, 1976).

The remainder of this section of the report reviews the experience of the Navy, Air Force, and Army with EAM systems. The review will begin with the EAM used in other services and converge on performance data of EAM used with Army systems which are most closely related to the LHX.

U.S. Navy Experience

The Navy's experience has been one of growing numbers of their most experienced maintenance technicians leaving the service, and increasing numbers of equipment failures that exceed

the maintenance skills of the remaining on-board personnel (NPRDC, 1985). Although the Navy has been searching for years to find a solution to the problem, their maintenance deficiencies continue. They have ships, aircraft, missiles and control centers with unfindable faults and marginally performing equipment (NPRDC, 1985). These problems were identified early in the Navy's Versatile Avionics Shop Test (VAST), a general purpose system of automatic test equipment. The conclusion of an assessment of this system by a Defense Resource Management study group in 1979 was, "problems with the VAST system included unreliability of test equipment and shortages of spare parts and personnel, both of which contributed to excessive fault isolation times and increased repair-cycle times" (Rice, 1980, p. 19).

Another Navy system with automated test equipment problems is the F-18 aircraft. For the F-18 program, "the best estimate of the BIT false alarm rate for the AN/APG-65 Radar is somewhere between 45 and 62 percent" (Nauta, 1985a, p. 45-46). This situation results in three negative consequences. First, maintenance time is lengthened when manual techniques must be used to troubleshoot a system. Second, replacing units that do not result in a correction of the problem wastes spare parts, resulting in the requirement for a larger spare parts supply. And third, delay time increases when the user waits to obtain repair parts that are not in supply.

On a more positive note, the Operational Readiness Test System (ORTS) in the Aegis system has avoided many of the pitfalls and is functioning as planned thus enabling attainment of the desired mission capability. The success has been attributed to several factors, including "program management's emphasis on availability, no cutting corners on maintainability, and a long maturation program prior to Fleet introduction" (Nauta, 1985a, p. 44). Another factor that supported the success of the implementation was the use of technicians selected and trained under special procedures. However, "maintenance supervisors, while satisfied with ORTS capabilities, articulated their concern about what will happen to Aegis once it is manned through the standard Navy personnel and training system" (Nauta, 1985a, p. 45).

The Navy has hopes that one recent development will reduce the severity of the equipment maintenance problems. This is the Integrated Diagnostic Support System (IDSS), sponsored by the Space and Naval Warfare Systems Command (NPRDC, 1985). The long range goal for the system is to provide tools and procedures to detect and isolate all faults, known or expected to occur in new weapon systems. The IDSS was designed as a troubleshooting tool with the intent of having the technician continuing to contribute to the process. Although there is a considerable amount of automation of the troubleshooting process, it was determined that "it is not possible nor desirable to fully automate it" (NPRDC, 1985). It has been the Navy's experience that approaches to automate fault detection and isolation have never succeeded in

covering 100% of any system. "Efforts to develop automatic fault routines for an entire system would be cost prohibitive, even if it were possible" (NPRDC, 1985, p. 3). It appears that the IDSS will be a compromise system in that it will be designed to support maintenance processes which will rely on the human maintainer as part of the system. The IDSS will be a computer-based and software intensive system requiring shipboard maintenance personnel to become more oriented to automated equipment used for monitoring, testing and fault isolation, and less concerned with traditional maintenance activities (circuit/signal tracing, soldering/wiring, and component/parts replacement). The IDSS is to provide the maintenance technician with:

- Automated performance aids in the form of an expert diagnostic system;
- On-line data regarding past equipment failures and maintenance histories as an integral part of the fault isolation and localization process;
- Automated logistical support (reports and forms processing; personnel and supply administration);
- All pertinent technical information as needed;
- Individualized troubleshooting training as required.

It is recognized by the Navy that the man-computer interface is crucial in the design and successful performance of the IDSS and research focusing on this issue is continuing (NPRDC, 1985).

U.S. Air Force Experience

The Air Force began testing the reliability of BIT/BITE in the late 1970s. Tuttle and Loveless (1980) reported the results of a study of BIT and external test equipment reliability and how well they are performing their designated functions of fault detection and isolation. BIT functioning in two aircraft (S-3A and C-5A) were examined. However, only the S-3A data were relevant to this analysis. Field maintenance data were collected for calendar year 1977 for the S-3A (59,720 flight hours). Field reliability experiences of BIT for the S-3A were found to vary considerably from LRU to LRU. BIT failed to find and isolate from 2.6% to 47.1% of the faults that occurred. Of ten LRUs examined as part of the study, five exceeded the BIT design failure criteria. However, for the system as a whole, the correlation of BIT failure experiences with BIT failure design criteria was found to be 0.72. BIT false alarm detections were examined for another set of 11 LRUs. The false alarm rates ranged from 0.7% for one LRU up to 12.5% for another LRU, with a mean of 6.0% false detections for all 11 LRUs. The general conclusions of this study (Tuttle and Loveless, 1980) are:

- The use of BIT (integrating BIT into the LRU) paid off in lower maintenance time/cost at a minimal decrease in equipment reliability.

- The amount of the LRU circuitry consumed by BIT circuitry ranged from 5% to 15%.

- The percent of the LRU circuits tested by BIT ranged from 83% to 95%.

- The most effective BIT characteristics were:

  - Wraparound testing
  - Signal Monitoring
  - Computer activation.

Air Force experience with the F-15 has generally been negative. The previously mentioned complexity problem with the F-15 automatic test station resulted in excessive downtime for the avionics intermediate shop, which broke down on an average of once every 34 hours, in addition to the unnecessary part removals (Defense Science Board, 1982). A similar problem was experienced with the F-16A aircraft. Only 49 percent of the faults that occurred in the avionics system were detected by on-board diagnostic equipment, and 45 percent of those were false alarm detections (Defense Science Board, 1982).

The Air Force has been fairly successful at solving reliability and maintainability problems, but have not been successful in meeting an initial goal of reducing manpower requirements. The reliability of the F-15 more than doubled over a 10 year maturation period, yet there has been no manpower saving. Twenty-four maintenance personnel are still needed to support each F-15 aircraft, the same number required to support the older F-4E, which does not use the high level BIT/BITE systems (Department of the Air Force, 1985).

The use of BIT/BITE was predicted to have better results in the B-1Bs Central Integrated Test Subsystem. One critic has said that this system has the same problems as predecessors:

"Like every computerized test bench before, it's an unbelievable pain. You've got to constantly reprogram it and they can never get rid of the software bugs. And it never winds up giving diagnoses more accurate than 60 percent or 70 percent, which is pretty bad. Those benches are such a bad idea that the airlines have completely given up on them. It's much too centralized and too rigid a concept. It raises skill levels terrifically and ... becomes a big maintenance burden in itself" (Rosenau, 1985, p. 44).

Air Force developmental efforts have increasingly emphasized automatic methods of fault detection and fault isolation through extensive use of BIT and System Integrated Test (SIT) for

organizational maintenance functions and use of ATE at the intermediate and depot levels. In implementing this concept, however, there has been a tendency to overlook the limitations of automatic test methods and to fail to provide adequate supplementary manual methods to enable complete detection and isolation of system failures (Smith, 1986). This conclusion was presented as a result of an engineering study conducted in 1982 for defining the approach that might be followed by weapon system developers to implement the Air Force's integrated diagnostics policy. This policy is being implemented through an FY 87 program entitled the Generic Integrated Maintenance Diagnostics (GIMADS) Program. A request for proposals for the development of a systems engineering approach and management process which will integrate maintenance diagnostics into the design, development and deployment of a weapon system has been issued. The development and implementation of the GIMADS concept will be through a combination of contractor and in-house government efforts.

The basis of the approach to be followed for system development emphasizes the planning and development of an integrated diagnostic capability which provides for complete detection and isolation of faults by a combination of automatic and manual methods. The implementation of this capability must consider the following factors:

- Contractor Design
- Available Technology
- Manpower Skill Constraints
- Weapon System Mission and Availability Requirements
- Life Cycle Cost Effectiveness

Based on an initially defined systems operation concept, maintenance concept, and other system requirements, a preliminary diagnostics analysis is to be conducted for the system or equipment to be developed. It is intended that the preliminary diagnostics concept address the use of BIT/SIT, manual diagnostic methods, ATE, maintenance data bases, and maintenance training at the conceptual level. As the acquisition process proceeds, the intent of the GIMADS program is for the system contractor to conduct trade-off studies to identify the best mix of integrated diagnostic techniques for use in the developmental and production systems. The organizational concept will include a single manager responsible for the implementation of the integrated diagnostics concept described in an Integrated Diagnostic Program Plan. The plan addresses the interrelationships of prime equipment design, support and test equipment, technical manuals, training and support groups. It defines an approach and methodology for maintaining consistency to minimize erroneous indications. The plan must also recognize that new fault modes, test voids, ambiguities and test tolerance difficulties are expected to occur. Therefore, provisions for adding explicit diagnostic procedures for the newly encountered faults and test problems must be incorporated into the plan. The plan must also

provide for an orderly maturation of diagnostic software and manual procedure throughout development, test and evaluation, and early operational use (1 to 3 years).

In summary, based upon its BIT/BITE experiences, the Air Force has taken the position that when integrating automatic diagnostics into equipment subsystems, problems will invariably be encountered and should be expected. This fact must be recognized in the system acquisition and development process. The Air Force has also taken the position that maintenance diagnostic programs should integrate BIT, ATE, manual procedures and training to deal with the inherent automated systems failures.

U.S. Army Experience

The Army's concept for tactical systems of "fix-forward" has been based upon the incorporation of complex electronics into the operating subsystems. In order for technicians to diagnose and repair equipment failures quickly and accurately, automatic test sets and sophisticated diagnostic equipment are being used to facilitate corrective maintenance tasks.

M1 Tank

Marcus and Kaplan (1984), of ARI, reported a reverse engineering study of the M1 tank with the following conclusions. The M1 tank, "probably the first major armored ground system to emphasize and incorporate advanced technology equipment" has suffered reliability, availability and maintainability problems, some of them due to failure of the automated test equipment. For example, only 66% of the original mean miles before failure criterion of 101 has been achieved. More than 20% of downtime was spent in troubleshooting the faults, as compared to only 7% of time for the predecessor, M60A1 tank. Two explanations for the extended diagnosis time were found. The first was that the maintenance personnel were not properly prepared to perform the fault diagnosis and detection tasks. In many cases the personnel did not have a basic understanding of subsystems' functions or interactions. The second reason for the increased troubleshooting time, was the poor performance of the automatic test equipment. Because the technicians had little or no confidence in the test sets they did not bother to use them.

Multiple Launch Rocket System

Significant problems attributable to the inadequate performance of the test equipment have also been reported by Arabian and others (1984) in an ARI reverse engineering study for the Multiple Launch Rocket System (MLRS). The repair time for the launcher loader exceeded the design specifications by a

factor of two. Where a requirement of correct LRU fault detection was set at 90%, only 15% fault detection has been possible. The goal for false LRU removals, set at 7%, is not within sight at a 54% false removal performance rate (Arabian et al., 1984).

OH-58D Helicopter

Although the OH-58 helicopter, has been in the Army inventory for 20 years, the D model, which incorporates extensive EAM technology, is undergoing developmental testing at Yuma, Arizona. The OH-58D developmental effort offers an example of the difficulty of attempting to integrate BIT/BITE into existing subsystems that are being up-graded with state-of-the-art technology.

The RAM (reliability, availability and maintainability) data available on the BIT/BITE systems were based on contractor performed maintenance during the period July 7, 1984 to August 30, 1984. During that 52 day period, 98 faults were detected over 305.6 flight hours. Table 1 presents a breakdown of the BIT/BITE performance.

Table 1

OH-58D BIT/BITE Performance Analysis

Total faults detected	98	
BITE monitored	98/98	100%
BITE used for fault detection	53/98	54%
BITE used for isolation	2/98	2%
BITE detections when used	24/53	45%
BITE failed to detect	11/53	21%
BITE system found to be faulty	18/53	34%
BITE detections not duplicated/ confirmed	41/98	42%
Total faults confirmed	47/98	48%
Successful BITE isolations when used	0/2	0%
BITE failed to isolate when used	2/2	100%
Resulting manual detections	74/98	76%
Manual isolations replacing BITE	45/47	96%

Several questions are raised by this data. First, it is curious that the BIT/BITE systems were not used to their full capabilities for fault detection and isolation. The automatic testing was only used 54% of the time for detection and 2% of the

time for isolation. The answer to the lack of use probably is due to the poor performance of BIT/BITE. BIT/BITE attempted to detect 53 times and failed 29 times. It failed to detect eleven faults. The other 18 missed detections were due to faulty BIT/BITE systems. With this kind of performance technicians would quickly learn not to rely on the automatic testing for fault detection.

The lack of confidence in BIT/BITE evidently spread to its use for fault isolation. The automatic testing was used in only 2 of the 47 isolation attempts and it failed to isolate the fault both times. The non-use of BIT/BITE, however, may have been due to the fact that contractor personnel performed all corrective maintenance on the system. From their experience with the development of the system the contractor maintenance personnel may have been so familiar with the faults that were detected that they immediately assumed the fault to be caused by certain low reliability components, and thus, did not need to use BIT/BITE for isolation. However, only 45 of the causes of the 98 detected faults were isolated. So the combined automatic and manual troubleshooting approach still was not used effectively.

One conclusion that can be established from the OH-58D data is that the Air Force's position and the Army's Patriot position of a long integrated development period for both weapon system and BIT/BITE appears to be confirmed. The technological upgrading process to include modern BIT/BITE systems in weapon system modernization evidently has not been worked out to eliminate significant reliability problems.

Patriot Missile System

The Patriot high altitude Air Defense Guided Missile system maintenance philosophy is to make the firing unit self-sufficient by providing repair at the operating site and to reduce maintenance requirements at the battery. No direct support maintenance is provided for system peculiar equipment. System peculiar maintenance support is provided by an Intermediate Maintenance Team and by the prime contractor on an as-required basis. To meet the maintenance requirements, the Patriot ground support equipment is based on an extensive use of BIT for detecting and localizing system faults to LRUs. Defective LRUs are replaced and evacuated to higher maintenance echelons for repair (if they are, indeed, faulty).

To support the Patriot maintenance concept, a comprehensive Maintainability Program was initiated at the beginning of the Patriot Engineering Development Program in the early 1970s. The purpose of this program was to assure that "ease of maintenance features were incorporated into system design. The maintenance concept encompasses automatic and manual fault detection and isolation procedures. A full assessment of the maintenance concept has not been possible to date, due to the high

reliability of the system itself, but some data are available. Over a period from September 1984 through November 1985, RAM data on Patriot systems in Germany, at White Sands Missile Range and at Fort Bliss owned by the Army revealed a false alarm detection rate of 13% (142 out of 1121). Mean Time To Repair data at Follow-On Evaluation III was 3.8 hours, compared to the goal of 2.0 hours. In 1982, a Maintenance Improvement Program was initiated following a reassessment of the maintenance concept, which concluded that a complex electronic system like the Patriot requires a backup level of maintenance between the field unit and the depot/factory. To compensate for the limitations of automatic diagnostics, a forward support element (the Patriot Field Army Support Center) made up of a team of highly skilled technicians (one warrant officer and nine E-7s) was created to provide on-site assistance to organizational maintenance personnel who have lower skill levels and less experience (Nauta, 1983).

AH-64A Helicopter

The AH-64A Apache is the Army's first helicopter with extensive BIT/BITE incorporated into the design. Because of its similarity to LHX technology and operational environment, the AH-64A was selected as the base case from which to extrapolate LHX performance projections.

The BIT/BITE system in the AH-64A is called the Fault Detection/Location System (FD/LS). The initial requirements that were established for FD/LS were:

- Provide on-board go/no-go status of mission/flight critical subsystems.
- Provide on-board isolation of electrical/electronic aviation unit maintenance (AVUM) replaceable units (RU).
- Provide for crew monitoring of drive system.
- Provide 95% on-ground fault isolation.
- Provide no more than 2% erroneous fault detections.
- Provide 75% aircraft availability.
- Attain 0.9 hours mean time to repair.
- Achieve goal of 9.0 or less maintenance manhours per flight hour.

These requirements were to be met through a maintenance concept which includes: BIT/BITE, diagnostic software, ground test equipment, automatic test equipment, technical manuals, and standard diagnostic procedures and equipment. The FD/LSs were to

be designed so as not to degrade the performance of the system components being monitored. The on-board subsystems containing mission essential and flight critical Aviation Unit Maintenance Replaceable Units are presented in Table 2.

Table 2

On-Board Subsystems Monitored by FD/LS

SUBSYSTEM	MISSION ESSENTIAL	FLIGHT CRITICAL
Environmental Control/Anti-ice	X	X
Navigation/Communications	X	
Fire Control	X	
FD/LS (Caution and Warnings)	X	X
Target Acquisition Designation Sight	X	
Pilot Night Vision Sensor	X	
Integrated Helmet and Display Sights System	X	
Flight Controls	X	X
Armament	X	
Multiplex	X	
Drive Controls	X	X

The on-board FD/LS consists of a number of detection and isolation methods for monitoring the mission essential and flight critical subsystems made up of 150 components. The fault detection/isolation modes that are used include automatic, semiautomatic actions and manual. The automatic mode provides warning and status input to cockpit displays. The semiautomatic mode uses diagnostic items such as caution and warning panels, push-go-test buttons, and computer prompt responses. The manual mode covers every maintenance action and procedure not using the FD/LS. The manual mode relies strictly on human observation. For the purposes of assessing the reliability of BIT/BITE systems, the RAM data were separated into two categories, automatic/semiautomatic and manual.

AH-64A RAM data used in this analysis were collected on one RAM demonstrator and four trainer aircraft at Fort Rucker from September 1985 through November 1985. The flight hours accumulated on these aircraft during this period was 1290 hours. The second set of data was collected on 19 operational aircraft at Fort Hood, Texas from April 1986 through July 1986. Over 1000 flight hours were accumulated on the 19 aircraft during this period.

Two kinds of data were extracted from the RAM data printouts furnished by the U.S. Army Aviation Systems Command; FD/LS fault

detection and isolation performance data; and direct mean maintenance man hours per repair when FD/LS failed. Both data are used in the extrapolation of the AH-64A BIT/BITE performance to the impact the same kinds of performance might have on the LHX system. The FD/LS performance data is presented in Table 3.

Table 3

AH-64A BIT/BITE Performance Analysis

	AH-64A[1] FT Rucker		AH-64A[2] FT Hood	
Total faults detected	126		251	
BITE monitored	101/126	80%	251/251	100%
BITE used to detect	74/101	73%	240/251	96%
BITE detections when used	70/74	95%	230/240	96%
BITE failed to detect	4/74	5%	10/240	4%
BITE system faulty			15/230	7%
BITE detections not duplicated/ confirmed	104/330	32%	90/230	39%
BITE not designed for isolation			167/240	70%
Detections designed for BITE isolation	101/101	100%	84/84	100%
BITE used to isolate	67/101	66%	68/84	81%
Successful BITE isolations when used	61/67	91%	59/68	87%
BITE failed to isolate when used	4/67	6%	6/6	89%
BITE failed to correctly isolate	2/67	3%	3/68	4%
Resulting manual detections	56/126	44%	21/251	8%
Manual isolations replacing BITE	40/101	40%	25/84	30%

[1]Fort Rucker data are from September - November 1985 RAM scoring period on one RAM demonstrator and four trainer aircraft.

[2]Fort Hood data are from 19 operational aircraft collected from April - July 1986.

The data from the two samples are quite similar in nature. One significant difference was in the increased use of the FD/LS to detect and isolate system faults. FD/LS use for detection improved from 73% in the Fort Rucker sample to 96% in the Fort Hood sample. The improvement in FD/LS use for isolation was from 66% at Fort Rucker to 81% at Fort Hood. One problem area, the false alarm rate, increased from 32% at Fort Rucker to 39% at Fort Hood. False detections have a critical impact on the

maintenance program in that they waste time and could lead to inappropriate maintenance actions which would further delay the repair of the system.

Another area where there was a slight decrease is FD/LS fault isolation performance. Successful FD/LS isolations dropped from 91% at Fort Rucker to 87% at Fort Hood. There are two components of the unsuccessful isolations; a pure failure to isolate the fault; and isolation to the wrong component. The failure to isolate (6% at Fort Rucker versus 9% at Fort Hood) requires that the isolation of the fault be carried out manually. This may place a skill burden on the maintenance technician beyond his capabilities. This is one problem the Navy has found with which it must deal (Smith, 1986). It can be resolved by either up-grading the training program to provide such skills, or the aircraft (or subsystem thereof) can be evacuated to a maintenance echelon where technicians have the skills to cope with the problem.

The second isolation error first leads to a delay in repair when the identified AVUM RU is replaced and the detected fault is not corrected. Then either manual isolation procedures must be used or the aircraft (or subsystem) must be evacuated to depot. Therefore both kinds of failure-to-isolate problems eventually have the same negative impact on the maintenance program. Data from Table 3 were used as input to Horizon's Technology, Inc., Administrative and Logistics Down Time (ALDT) model to project the impact that BIT/BITE performance similar the AH-64A data would have on the LHX operational performance. These projections and results are discussed in the EAM for the LHX section.

The Fort Hood AH-64A study also produced some interesting data for the time it took to repair a fault. The direct mean maintenance man hours (MMMH) for repairing faults when strictly manual detection, isolation and repair procedures were used was 1.43. When BIT detected, but was not designed for isolation, direct MMMH was 2.37. In those cases when BIT/BITE was designed to detect and isolate but failed to do one or both, MMMH increased to 3.15. The systematic increase from the pure manual procedures for completing manual maintenance tasks to the use of manual procedures to overcome BIT/BITE failures might reflect an increased complexity of equipment subsystems BIT/BITE was designed to cover, or it might reflect the skill level required to troubleshoot and repair those subsystems.

Summary of the Army Experience

Thus far the Army has experienced similar difficulties with each of its previous BIT efforts. The BIT has not met performance expectations and BIT failures have equated to increased down time, and increased and more complex maintenance. Furthermore, based on the rate of false alarm detections for the four most recent weapon systems (see Table 4), there has not been

a significant improvement in terms of the advancement of the BIT/BITE technology for reducing false alarm rates for Army helicopters. The Patriot system has a much lower false alarm detection rate, but 13% is too high to meet all LHX RAM goals.

Table 4

False Alarm Detections (FADS)

SYSTEM	FADS/TOTAL	%
AH-64A FT Rucker (5 A/C)	104/330	32%
AH-64A FT Hood (19 A/C)	90/230	39%
OH-58D	41/98	42%
Patriot	142/1121	13%

Conclusions

The experience of the other military services are similar to the Army's and lead to following conclusions:

- BITE has not proved to be as reliable as the designers would like it to be and thus fault detection and isolation cannot be totally automated.
- Technicians must be able to take over the troubleshooting tasks when BIT/BITE fails.
- BIT/BITE false alarm detection and erroneous isolation rates will have to be tolerated.
- Maintenance training may have to be up-graded to include system and subsystem function integration concepts in order to effect timely repairs when the BIT fails.

It is not within the scope of this effort to identify specific EAM potentials under varying operational and climatic conditions. However, it appears that 90 to 95% coverage of electronic systems to the LRU level with a 95% reliability is approaching the limit of reasonable expectations. For other than electronic systems, the technological limit appears to be considerably lower.

More important than the technological limit is the understanding that the practical boundary for maintenance of any system is established by the interaction of hardware, maintenance

personnel, maintenance concepts and doctrine. The lower acceptable limit of the combined effect of the maintenance interaction is established by the mission requirement. The EAM for the LHX section serves as an example of one method to explore those boundaries. As such, it uses data from BIT performance discussed above to examine the impact of likely BIT performance on LHX maintenance. The model used to conduct such analyses aids in pinpointing where in the maintenance system BIT failures will be felt most strongly.

EAM FOR THE LHX

General

EAM is included as one of key subsystems of the LHX. The expectation is that the application of state-of-the-art technology to rapidly and accurately perform fault diagnostics and prognostics will make a substantial contribution to reducing LHX operations and support costs.

Design Goals

In keeping with the above philosophy, the design goals established for the on-board LHX fault detection/location system (LHX FSD RFP, 2nd Draft) are broad and may be so high as to be pushing the upper limit of technological possibilities. The LHX FD/LS, consisting of BIT, BITE, and diagnostic monitoring and recording equipment, must detect both mechanical and electrical system failures and, as such, must be capable of detecting a minimum of 95% of all electronic system failure modes as determined by failure frequency and criticality. FD/LS must correctly isolate 98% of the FD/LS detected failures with false failure indications and LRU false removals not to exceed 2% and 1%, respectively. Additionally, FD/LS is to interface with any on-board mission management system and be compatible with Predictive Aircraft Maintenance System (PAMS).

Drawbacks

Accurate and effective BIT performance would enable substantial savings in (1) maintenance manpower, (2) training time for maintenance personnel, (3) special tools and test equipment, and (4) repair parts storage and handling. In addition, the success of the BIT is critical to the LRU concept and the two-level maintenance concept and impacts heavily on MOS (military occupational speciality) consolidation plans and possibilities. These benefits are predicated on the assumed time savings, simplification of maintenance tasks and high level of accuracy of prognostication and diagnosis. Over-estimating the capability of BIT/BITE may mean that the LHX will not be able to

meet some or all of its EAM design goals. Specifically, as BIT performance varies from planned performance, maintenance time and logistics delay time will increase.

Under the proposed two-level maintenance concept, the failure to correctly detect or isolate a fault will require depot level intervention. This occurs because the user level is precluded from having off-aircraft ATE and because user personnel are not to be trained in piece part repair or the associated diagnostics. There is a finite amount of "not available time" associated with calling for maintenance assistance and with performing manual fault isolation.

Erroneous indications of faults and failure to isolate or isolation of a fault to the wrong LRU will also require depot intervention. In addition, false indications lead to an increase in the supply burden and in the component repair burden. Depot assistance will be necessary because user maintenance personnel do not have the wherewithal to confirm or deny a maintenance condition without BIT. The supply and component repair burdens will increase because a part will be used when none is required and the component repair activity will have to go through a diagnostic operation on the removed LRU only to prove that it is serviceable.

If the BIT does not create the anticipated work simplification, by eliminating manual fault diagnosis and piece part repair below the depot level, the new groupings of tasks under existing or new MOS for the two-level maintenance concept may end up being out of balance. The potential also exists to eliminate tasks based on predicted highly reliable BIT that will still be required when BIT performance is sub-par.

Projected Performance

The expectations for the BIT are quite high. In addition, a large portion of the logistics support programmed for the LHX assumes that the BIT will be a total success. The mean time to repair and delay times projected for the LHX are specific examples of goals affected by BIT performance. The feasibility of the mean time to repair included in the RAM data (0.5 hours) is only possible if the BIT virtually eliminates diagnostic time and the LRU concept is successful. The BIT is critical to the LRU maintenance concept. The expected value of delay time incurred once a failure has occurred (5.5 hours) cannot be achieved if false BIT readings cause additional (and possibly unnecessary) delays awaiting parts, delays awaiting transportation to higher level maintenance, or delays awaiting higher level technicians.

Based on the findings previously documented in the Military Experiences with Electronic Aids in Maintenance section, there is a good probability that the BIT will not meet current performance

expectations. Although conceptually possible, the overwhelming evidence is that the state-of-the-art of BIT technology is not sufficiently mature to achieve total success with the hardware. Unfortunately the scope of this contract combined with the closely held and proprietary nature of much of the technical data specific to the LHX BIT make it unrealistic to pinpoint exactly how effective the BIT will be. We have, however, studied the sensitivity of aircraft availability and maintenance manpower to BIT performance. The methodology and specific information developed should be extremely useful to logistics planners. The information will aid first in the avoidance of premature foreclosure of options and second in the avoidance of excessively risky support concepts.

Methodology

The methodology employed in the current effort was to (1) integrate the possible BIT failures into the ALDT model as published in the LHX RAM Rationale Report (Annex E to the LHX Required Operational Capability); (2) input the AH-64A BIT failure data into the model as the base case; (3) determine the sensitivity of aircraft availability to changes in BIT performance by incrementally improving the values for BIT performance and re-running the model; and (4) subjectively evaluate manpower, personnel and training solutions as to their ability to affect the failure modes to which mission capability is most sensitive.

The modeling and sensitivity analysis begins with the occurrence of an essential maintenance action. Although the BIT can contribute to the frequency of EMAs (essential maintenance actions), the data available was not sufficient to enable realistic modeling. Specifically, neither the corrective actions taken in the event of a false indication nor the relative frequency of the corrective actions could be determined.

Integrating EAM Failures into ALDT Model

In order to assess the impact of various levels of BIT performance on aircraft availability, maintenance manpower and the logistics support concepts, it was first necessary to determine the type of bit failures that are likely and insert them into the ALDT model at each point at which they may occur. Figure 1 illustrates the types of BIT failures and where they may occur in the maintenance sequence.

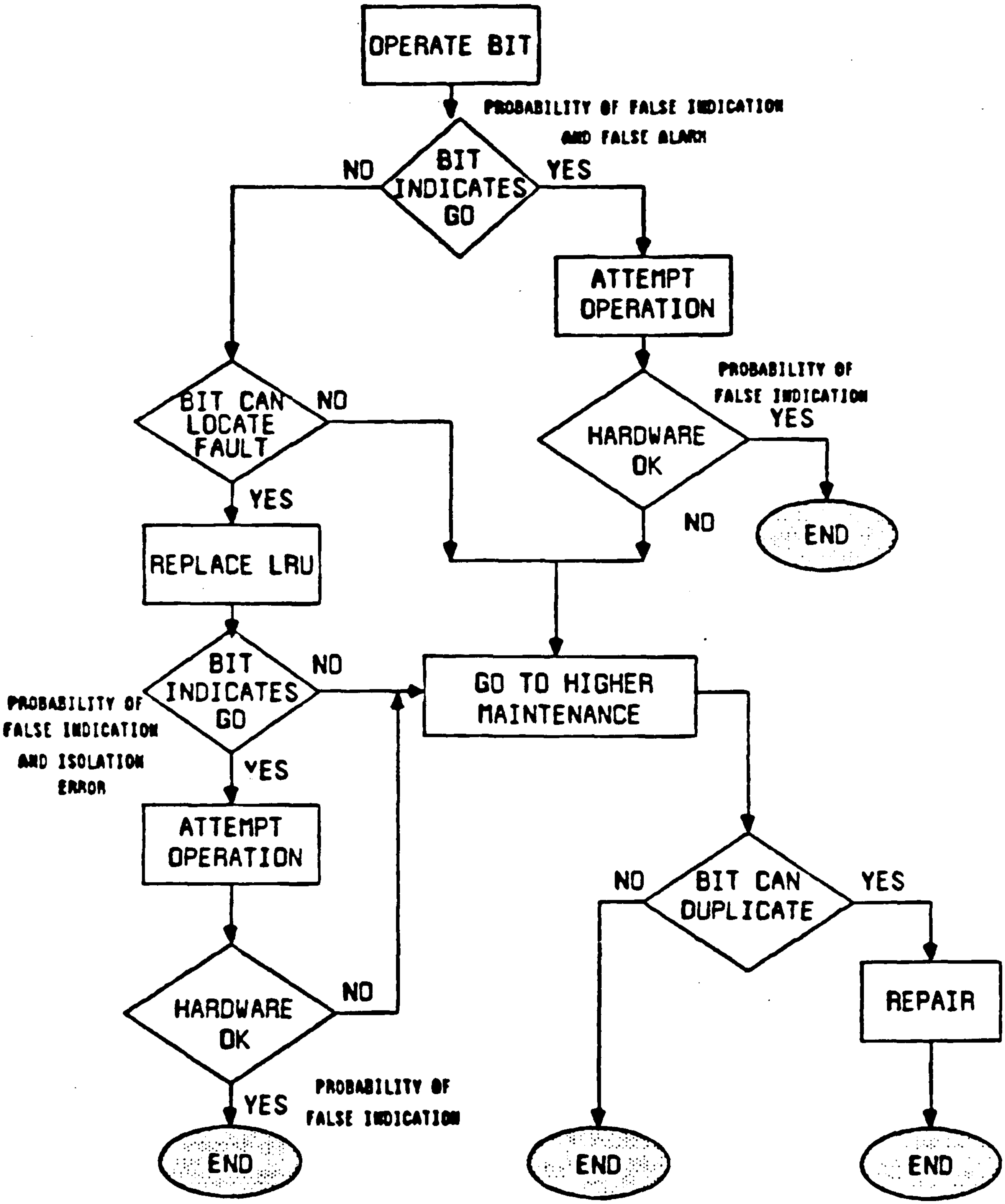


Figure 1. Types of BIT failures.

False Indication

Under the heading of "false indication," there are two possibilities: 1) The BIT can fail to detect a fault, and 2) The BIT can indicate a fault when in actuality there is none. Either of those errors can occur during normal operation and thus obscure the fault until an attempt is made to operate the affected subsystem or instigate an otherwise unnecessary maintenance action. It is also possible for the BIT failure to occur during an after-maintenance check, again, either obscuring a fault or instigating a maintenance action. If the BIT failure occurs during normal operation, obscuring a fault can have serious mission and or safety implications. BIT failure during an after-maintenance check which instigates an unnecessary maintenance action adversely affects aircraft availability as well as wasting scarce maintenance resources. In both cases, current LHX maintenance concepts will require depot level maintenance intervention.

Isolation Error

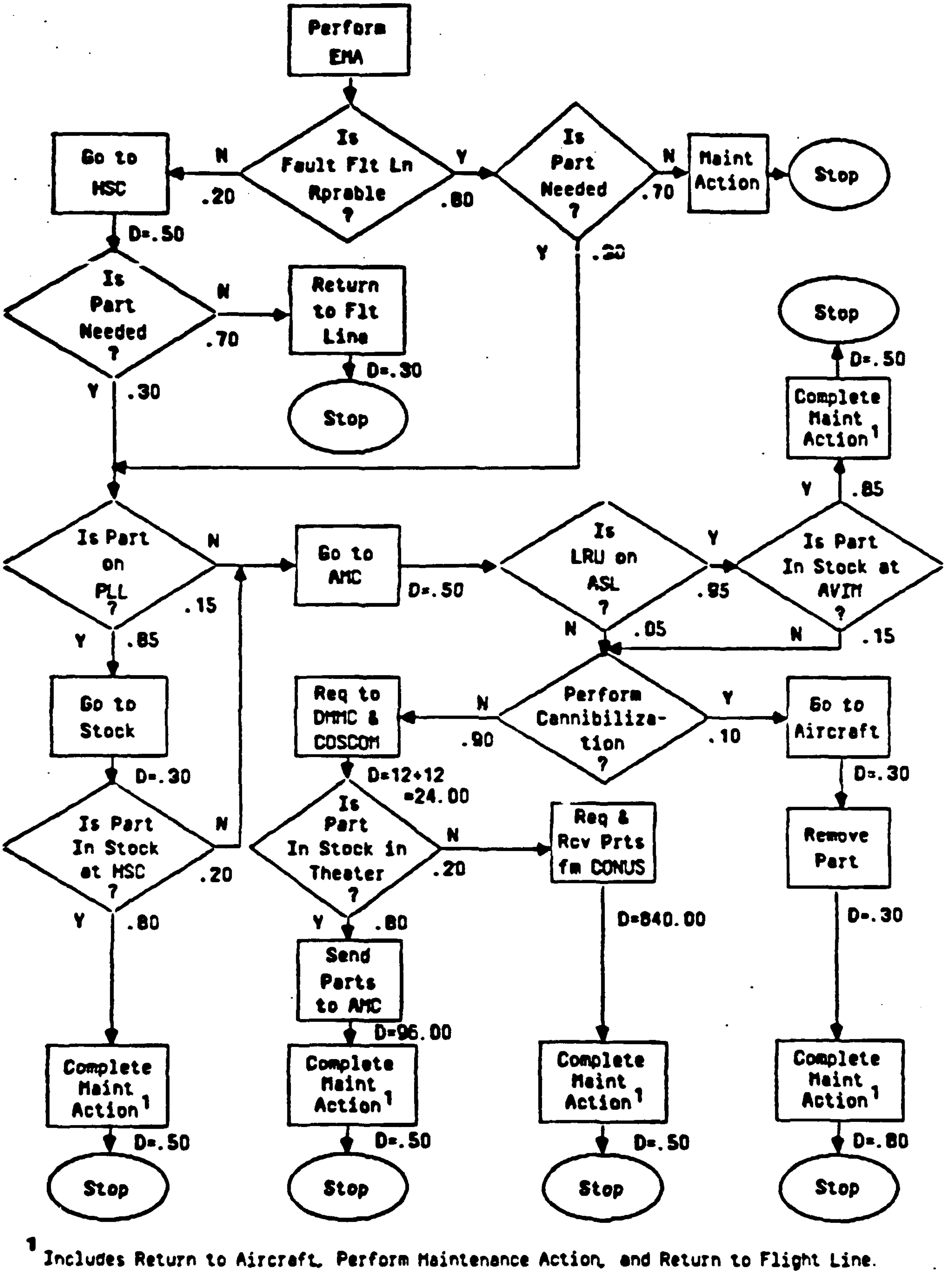
There are two basic failure possibilities during fault isolation: 1) the BIT cannot locate the failed LRU, and 2) the BIT isolates improperly (attributes the fault to the wrong LRU). Unlike detection failures, isolation failures can only occur during maintenance. The impact however is very much the same. Erroneous fault isolation causes unnecessary down time, wastes maintenance manpower and increases the consumption of LRUs.

Depot maintenance is required in order to both repair the BIT (assuming a hardware failure) and to correctly isolate the fault of the original maintenance problem.

Assessing the Impact of Degraded Bit Performance

At the current maturity of the LHX design it is not possible to predict with any reasonable certainty how well the BIT is going to perform. Therefore the sensitivity of RAM data to various levels of BIT performance was investigated. The approach to performing that investigation was to integrate the possible BIT errors into the ALDT model published in the RAM Rationale Report. Once integrated the expected values for the delay time and repair time were computed for each of the possible paths in the model. Armed with those numbers it is a relatively straight forward task to determine the expected availability and maintenance manpower requirement.

Figure 2 is the ALDT model as presented in the RAM Rationale and Figure 3 depicts the addition of the BIT failure possibilities; false indication or isolation error.



[1] Includes Return to Aircraft, Perform Maintenance Action, and Return to Flight Line.

Figure 2. War time administrative and logistics down time.

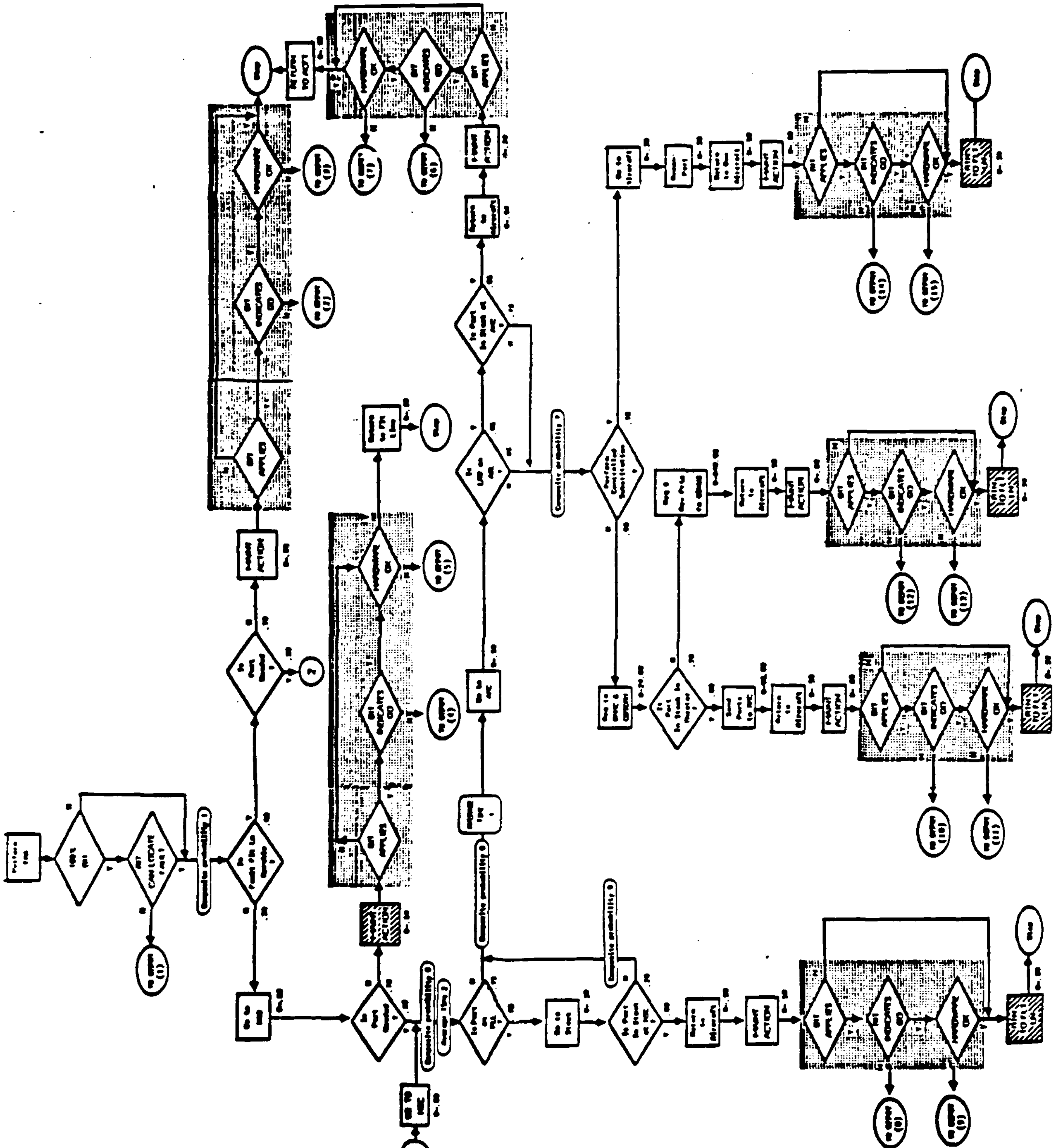


Figure 3. War time ALDT with built-in test.

Prior to adjusting the ALDT model to accommodate the BIT failure possibilities, the repair cycle in the model was not complete. Therefore, in every instance where the aircraft had been removed from the flight line, an operation was created to return it to the flight line upon completion of the maintenance action. Additionally, an operation was added to repair the aircraft if it was not flight line repairable and did not need a part. The added operations are highlighted in Figure 3 by crosshatching.

The shaded decision points of Figure 3 are those that pertain exclusively to BIT. The logic is that there are only four possible ways for the BIT to perform.

1) It can avoid performing at all because it was not designed to fault isolate a component. On the model this possibility is labeled "BIT APPLIES". This question is pertinent upon discovery of an aircraft condition requiring maintenance (an essential maintenance action) and at the beginning of checkout after maintenance has been performed.

2) The second question is, "If the "BIT APPLIES", can it successfully isolate the fault to an LRU?" On the model this is labeled "BIT CAN LOCATE FAULT". This question is pertinent only during the initial attempt at fault isolation. If the BIT cannot isolate the fault it is necessary to exit to higher level maintenance since the user does not have off-aircraft diagnostic capability.

3) The third question is, "If a repair action is complete and the "BIT APPLIES", upon initiating a checkout sequence does the BIT indicate that the original fault has been corrected?" This is labeled on the model as "BIT INDICATES GO". A negative response to this question contains the possibility that (a) the fault has been corrected but the BIT has failed and is giving a false indication and (b) the BIT had failed during the earlier isolation sequence and isolated the cause of the EAM failure to the wrong LRU. Therefore, the probability of a "no response" is equal to the probability of isolation error plus the probability of a false indication. In either case, the only remedy is to go to higher maintenance.

4) The last question is, "If a repair has been accomplished, and the "BIT APPLIES", and the "BIT INDICATES GO", does the aircraft system function properly?" This is labeled "HARDWARE OK" on the model. A negative response is indicative of the possibility that the BIT failed to detect a fault during the maintenance verification sequence. The model does not attempt to attribute that fault to faulty diagnosis, faulty replacement action or faulty replacement LRU. Therefore, the probability of this event is equal to the probability of an isolation error.

In order to compute the expected value of the total down time once an EMA had occurred, the probabilities for each of the

BIT decision blocks and the delay and repair times associated with depot maintenance were treated as variable inputs. The probabilities and times associated with the decisions and events from the original ALDT model were held constant. The outputs of the model are:

1) Cumulative probability that depot maintenance will be required once there is an EMA.

2) The expected value of the total maintenance time required for depot maintenance.

3) The expected value of total administrative and delay time associated with depot maintenance.

4) Aircraft availability.

5) Maintenance ratio.

6) The expected value of the total down time associated with each discreet path within the model.

In applying the model, a base set of inputs was established from a subjective evaluation of the military experience to date. The base case was intended to be a conservative estimate from which to conduct a regression analysis of each of the BIT failure types. During the regression analysis one failure type was systematically varied while all other inputs were held constant to determine the effect of the BIT failure on mission capability. In addition, one run was made changing the probability of all types of BIT failures to zero in order to establish for comparison purposes conditions created by perfect BIT. Appendix A contains the outputs in tabular form for each of the model runs. A further description of the model is provided at Appendix B.

Summary of Results

The results of the modeling effort indicate that 11 SCAT helicopters employed in an attack helicopter company to perform 2 back-to-back three-hour, 8-aircraft missions in each 18-hour cycle for a 7-day period will achieve an availability ranging from 68% for perfect BIT to 59% for BIT with performance equal to the AH-64A.

The results of the sensitivity analysis are depicted in Figure 4. In each case, the start point is the AH-64A base case, then one factor (either failure mode or down time) is improved while each of the other factors is held constant. It is important to note that the factors illustrated in the graphs are interdependent and therefore, the graphs are comparative not additive. That is, it is not possible to add the improvement gained with one factor to the improvement associated with another factor to obtain a total improvement in availability.

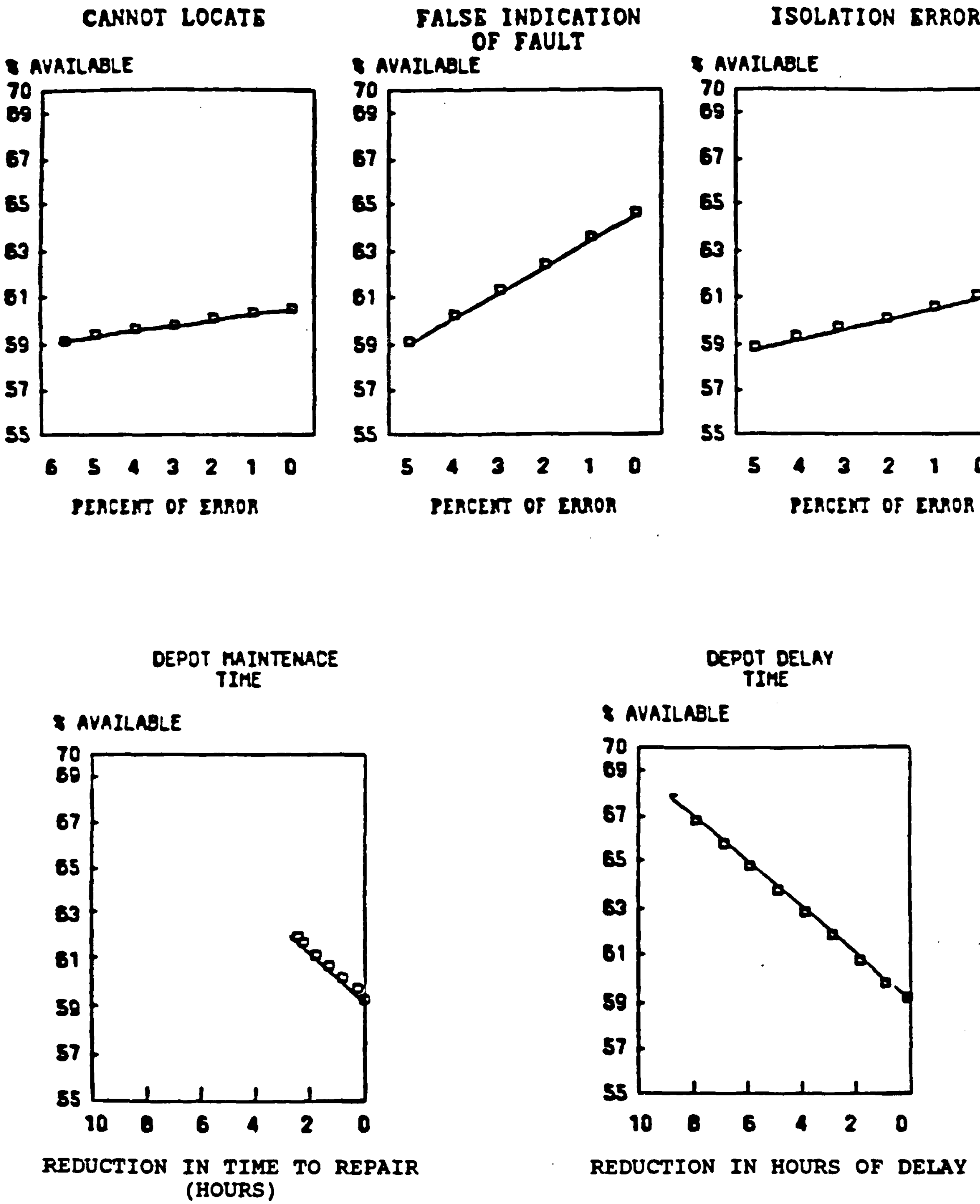


Figure 4. Sensitivity of aircraft BIT performance.

As the graphs indicate, the largest opportunity for improvement (approximately 8 percentage points) lies in the delay times associated with depot maintenance. For every hour of delay that is avoided, there is almost 1% improvement in aircraft availability. The second largest opportunity for improvement lies in the percentage of error associated with false indication of a fault failure mode which accounts for approximately 6 percentage points of aircraft availability. On the other end of the spectrum is the failure mode in which the BIT cannot locate the faulty LRU. Totally eliminating this failure while holding all other parameters constant at the base case value, will only achieve a 1.4% improvement in aircraft availability.

MPT-Related Solutions

There are several MPT-related remedies which can mitigate the impact of BIT failures. However, they are generally not applicable to repair time. The time required to repair a fault is generally inherent in the design. Usually the physical space and the nature of repair tasks preclude cutting repair time by adding people. On the other hand, reducing administrative and logistics delays is extremely sensitive to the positioning of maintainers. In the event that there is a EAM failure the more quickly the repair technicians can be made available, quite obviously, the shorter the down time. In the case of the LHX as the delay time awaiting depot maintenance is adjusted downward to 0, the expected value of the average down time for an EMA decreases from a high of 7.1 hours to 5.7 hours (See Appendix A). That translates into an improvement in aircraft availability of approximately 8%.

There are several options available to reduce the time awaiting depot maintenance. The first is to form contact teams that can be deployed rapidly to the defective aircraft. This option does not conflict with the two-level maintenance concept proposed for the LHX. It would, however, require an investment in portable automatic test equipment. Another potential difficulty on the modern battle field will be communicating between the aircraft owning unit and the depot maintenance activity to request the team and to advise them of the aircraft's location. The combination of communication and mobility limitations on the battlefield make it unlikely that the delay time could be reduced to much less than four hours using this option.

Another remedy would be to amend the two-level maintenance concept and position highly trained diagnosticians at the Aviation Maintenance Company, the Aviation Battalion Headquarters and Service Company and perhaps in the aviation line company. This option is extremely effective in reducing the delay time but is expensive in terms of the increased training burden associated with training more military personnel in diagnostics and perhaps piece part repair and the personnel management burden associated

with maintaining visibility of and control over these scarce assets. The other major drawback to this option is the proliferation of off-aircraft test equipment.

The final option for discussion is, in reality, carrying the training of specialized diagnosticians to the extreme and training every mechanic to conduct off-line troubleshooting. This option would have maximum impact on the delay time but would also be the most expensive in terms of training and off-aircraft test equipment. The wholesale expansion of training would also be exacerbated by the retention problems that normally occur when relatively junior soldiers (E5 and below) are extensively trained.

The best solution will probably be a hybrid of the three mentioned above. As was pointed out earlier, as a rule of thumb, 20% of the system causes 80% of the maintenance workload. Therefore placing some diagnostic capability in the unit and gradually increasing it as you go up the maintenance chain culminating in highly mobile contact teams at depot level will probably be the most cost effective. This solution would provide the opportunity to hold the training burden and proliferation of the training burden in check while concentrating on the relatively small portion of the aircraft that most affects the aircraft's availability. Again, due to the closely guarded nature of the LHX and Advanced Rotorcraft Technology Integration (ARTI) data, the research team was unable to identify specific and detailed alternatives. As data is released, it should be possible to apply the model to the aircraft system and its specific components to conduct trade-offs between maintenance concepts, personnel policies and mission capability.

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APPENDIX A

DATA TABLES

Appendix A includes the data tables for each of the sensitivity analyses of the BIT failure modes and delay factors.

The tables are set up with the events and data elements in the rows. Each column represents an excursion. The first two data columns of each table show the values for BIT that performs according to specification and for the AH-64 base case. The headings for the remainder of the columns indicate the value of the factor that was varied in that excursion. The labels in the extreme left hand column correspond to a decision point, process, or dummy operation in the model depicted in Appendix B.

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TABLE A-1

BIT Cannot Locate

EVENT/EXCURSION	PERFECT BIT	BASE	CANNOT LOC =5%	CANNOT LOC =4%	CANNOT LOC =3%	CANNOT LOC =2%	CANNOT LOC =1%	CANNOT LOC =0%
CAN ISOLATE	1.0000	0.9400	0.9500	0.9600	0.9700	0.9800	0.9900	1.0000
HARDWARE OK	1.0000	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
INDICATES GO	1.0000	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200
DEPOT TRANS TIME	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000
DEPOT MAINT	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500
PROBABILITY OF DEPOT	.0000	0.1699	0.1615	0.1532	0.1448	0.1364	0.1281	0.1197
TOTAL DEPOT TRANS	.0000	1.9191	1.8578	1.7966	1.7353	1.6740	1.6128	1.5515
TOTAL DEPOT MAINT	.0000	0.5916	0.5658	0.5400	0.5142	0.4885	0.4627	0.4369
TOTAL DEPOT TIME	.0000	2.5106	2.4236	2.3366	2.2495	2.1625	2.0755	1.9884
MTTR	0.5000	0.5795	0.5618	0.5459	0.5318	0.5194	0.5088	0.5000
AVERAGE DOWN TIME	5.5149	7.0886	7.0477	7.0068	6.9659	6.9250	6.8840	6.8431
AVAILABILITY	68.1682	59.0844	59.3206	59.5568	59.7929	60.0291	60.2652	60.5014
PROB DEPOT 1	.0000	0.0570	0.0475	0.0380	0.0285	0.0190	0.0095	0.0000
TRANS DEPOT 1	.0000	0.4560	0.3800	0.3040	0.2280	0.1520	0.0760	0.0000
MAINT DEPOT 1	.0000	0.1796	0.1496	0.1197	0.0898	0.0599	0.0299	0.0000
TOTAL DEPOT 1	.0000	0.6356	0.5296	0.4237	0.3178	0.2119	0.1059	0.0000
PROB DEPOT 2	.0000	0.0401	0.0405	0.0409	0.0413	C.0418	0.0422	0.0426
TRANS DEPOT 2	.0000	0.3211	0.3243	0.3275	0.3308	0.3340	0.3372	0.3405
MAINT DEPOT 2	.0000	0.1465	0.1480	0.1494	0.1509	0.1524	0.1539	0.1553
TOTAL DEPOT 2	.0000	0.4676	0.4723	0.4770	0.4817	0.4864	0.4911	0.4958
PROB DEPOT 3	.0000	0.0231	0.0233	0.0235	0.0238	0.0240	0.0242	0.0245
TRANS DEPOT 3	.0000	0.1846	0.1865	0.1883	0.1902	0.1921	0.1939	0.1958
MAINT DEPOT3	.0000	0.0842	0.0851	0.0859	0.0868	0.0876	0.0885	0.0893

TABLE A-1 (Continued)

BIT Cannot Locate

EVENT/EXCURSION	PERFECT BIT	BASE	CANNOT LOC =5%	CANNOT LOC =4%	CANNOT LOC =3%	CANNOT LOC =2%	CANNOT LOC =1%	CANNOT LOC =0%
TOTAL DEPOT 3	.0000	0.2688	0.2716	0.2743	0.2770	0.2797	0.2824	0.2851
PROB DEPOT 4	.0000	0.0100	0.0101	0.0102	0.0103	0.0104	0.0105	0.0106
TRANS DEPOT 4	.0000	0.0853	0.0861	0.0870	0.0879	0.0887	0.0896	0.0904
MAINT DEPOT 4	.0000	0.0366	0.0370	0.0374	0.0377	0.0381	0.0385	0.0388
TOTAL DEPOT 4	.0000	0.1219	0.1231	0.1244	0.1256	0.1268	0.1280	0.1293
PROB DEPOT 5	.0000	0.0058	0.0058	0.0059	0.0059	0.0060	0.0061	0.0061
TRANS DEPOT 5	.0000	0.0490	0.0495	0.0500	0.0505	0.0510	0.0515	0.0520
MAINT DEPOT 5	.0000	0.0211	0.0213	0.0215	0.0217	0.0219	0.0221	0.0223
TOTAL DEPOT 5	.0000	0.0701	0.0708	0.0715	0.0722	0.0729	0.0736	0.0743
PROB DEPOT 6	.0000	0.0056	0.0056	0.0057	0.0057	0.0058	0.0058	0.0059
TRANS DEPOT 6	.0000	0.0534	0.0539	0.0545	0.0550	0.0555	0.0561	0.0566
MAINT DEPOT 6	.0000	0.0203	0.0205	0.0207	0.0209	0.0211	0.0213	0.0215
TOTAL DEPOT 6	.0000	0.0737	0.0744	0.0751	0.0759	0.0766	0.0774	0.0781
PROB DEPOT 7	.0000	0.0032	0.0032	0.0033	0.0033	0.0033	0.0034	0.0034
TRANS DEPOT 7	.0000	0.0307	0.0310	0.0313	0.0316	0.0319	0.0322	0.0326
MAINT DEPOT 7	.0000	0.0117	0.0118	0.0119	0.0120	0.0121	0.0122	0.0124
TOTAL DEPOT 7	.0000	0.0424	0.0428	0.0432	0.0436	0.0441	0.0445	0.0449
PROB DEPOT 8	.0000	0.0146	0.0148	0.0149	0.0151	0.0152	0.0154	0.0155
TRANS DEPOT 8	.0000	0.1360	0.1373	0.1387	0.1401	0.1414	0.1428	0.1442
MAINT DEPOT 8	.0000	0.0534	0.0539	0.0544	0.0550	0.0555	0.0561	0.0566
TOTAL DEPOT 8	.0000	0.1893	0.1912	0.1931	0.1951	0.1970	0.1989	0.2008
PROB DEPOT 9	.0000	0.0084	0.0085	0.0086	0.0087	0.0087	0.0088	0.0089
TRANS DEPOT 9	.0000	0.0782	0.0790	0.0798	0.0805	0.0813	0.0821	0.0829

TABLE A-1 (Continued)

BIT Cannot Locate

EVENT/EXCURSION	PERFECT BIT	BASE	CANNOT LOC =5%	CANNOT LOC =4%	CANNOT LOC =3%	CANNOT LOC =2%	CANNOT LOC =1%	CANNOT LOC =0%
MAINT DEPOT 9	.0000	0.0307	0.0310	0.0313	0.0316	0.0319	0.0322	0.0325
TOTAL DEPOT 9	.0000	0.1089	0.1100	0.1111	0.1122	0.1133	0.1143	0.1154
PROB DEPOT 10	.0000	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
TRANS DEPOT 10	.0000	0.1236	0.1248	0.1261	0.1273	0.1286	0.1298	0.1311
MAINT DEPOT 10	.0000	0.0035	0.0035	0.0036	0.0036	0.0036	0.0037	0.0037
TOTAL DEPOT 10	.0000	0.1271	0.1284	0.1296	0.1309	0.1322	0.1335	0.1348
PROB DEPOT 11	.0000	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
TRANS DEPOT 11	.0000	0.0711	0.0718	0.0725	0.0732	0.0739	0.0746	0.0754
MAINT DEPOT 11	.0000	0.0020	0.0020	0.0020	0.0021	0.0021	0.0021	0.0021
TOTAL DEPOT 11	.0000	0.0731	0.0738	0.0745	0.0753	0.0760	0.0767	0.0775
PROB DEPOT 12	.0000	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003
TRANS DEPOT 12	.0000	0.2083	0.2104	0.2125	0.2146	0.2167	0.2188	0.2209
MAINT DEPOT 12	.0000	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
TOTAL DEPOT 12	.0000	0.2091	0.2112	0.2133	0.2155	0.2176	0.2197	0.2218
PROB DEPOT 13	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TRANS DEPOT 13	.0000	0.1198	0.1210	0.1222	0.1234	0.1246	0.1258	0.1270
MAINT DEPOT 13	.0000	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
TOTAL DEPOT 13	.0000	0.1203	0.1215	0.1227	0.1239	0.1251	0.1263	0.1275
PROB DEPOT 14	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TRANS DEPOT 14	.0000	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
MAINT DEPOT 14	.0000	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
TOTAL DEPOT 14	.0000	0.0018	0.0019	0.0019	0.0019	0.0019	0.0019	0.0020
PROB DEPOT 15	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

TABLE A-1 (Continued)

BIT Cannot Locate

EVENT/EXCURSION	PERFECT BIT	BASE	CANNOT LOC =5%	CANNOT LOC =4%	CANNOT LOC =3%	CANNOT LOC =2%	CANNOT LOC =1%	CANNOT LOC =0%
TRANS DEPOT 15	.0000	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
MAINT DEPOT 15	.0000	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
TOTAL DEPOT 15	.0000	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
PROB FLT LN REPAIR	0.5600	0.4649	0.4696	0.4742	0.4789	0.4836	0.4883	0.4930
TIME FLT LN RPR	0.2800	0.2324	0.2348	0.2371	0.2395	0.2418	0.2441	0.2465
PROB PART FROM PLL	0.2040	0.1693	0.1711	0.1728	0.1745	0.1762	0.1779	0.1796
TIME PART FROM PLL	0.4284	0.3556	0.3592	0.3628	0.3664	0.3700	0.3735	0.3771
PROB PART FROM ASL	0.0775	0.0644	0.0650	0.0656	0.0663	0.0669	0.0676	0.0682
TIME PART FROM ASL	0.1868	0.1550	0.1566	0.1582	0.1597	0.1613	0.1629	0.1644
PROB PART FROM THEAT	0.0133	0.0110	0.0112	0.0113	0.0114	0.0115	0.0116	0.0117
TIME PART FROM THEAT	1.6287	1.3520	1.3657	1.3793	1.3929	1.4065	1.4202	1.4338
PROB PART FROM CONUS	0.0033	0.0028	0.0028	0.0028	0.0028	0.0029	0.0029	0.0029
TIME PART FROM CONUS	2.8032	2.3270	2.3504	2.3739	2.3973	2.4208	2.4442	2.4676
PROB CONTROL SUB	0.0018	0.0015	0.0015	0.0016	0.0016	0.0016	0.0016	0.0016
TIME CONTROL SUB	0.0057	0.0048	0.0048	0.0049	0.0049	0.0050	0.0050	0.0051
PROB 1	1.0000	0.9430	0.9525	0.9620	0.9715	0.9810	0.9905	1.0000
PROB 2	0.1400	0.1320	0.1333	0.1347	0.1360	0.1373	0.1387	0.1400
PROB 3	.0000	0.0760	0.0760	0.0760	0.0760	0.0760	0.0760	0.0760
PROB 4	.0000	0.0437	0.0437	0.0437	0.0437	0.0437	0.0437	0.0437
PROB 5	1.0000	0.8803	0.8803	0.8803	0.8803	0.8803	0.8803	0.8803
PROB 6	0.0960	0.0905	0.0914	0.0924	0.0933	0.0942	0.0951	0.0960
PROB 7	0.0185	0.0174	0.0176	0.0178	0.0180	0.0181	0.0183	0.0185
BIT APPLIES	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500

TABLE A-1 (Continued)

BIT Cannot Locate

EVENT/EXCURSION	PERFECT BIT	BASE	CANNOT LOC =5%	CANNOT LOC =4%	CANNOT LOC =3%	CANNOT LOC =2%	CANNOT LOC =1%	CANNOT LOC =0%
FLT LN REPAIR	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
NEED PART	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
MAINT ACTION	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
GO TO MSC	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
RETURN TO FLT LN	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
PART ON PLL	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
GO TO AMC	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
PART ON ASL	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
IN STK ASL	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
RTN TO ACFT	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
GO TO PLL STOCK	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
IN STK PLL	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
CONTROL SUB	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
GO TO ACFT	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
REMOVE PART	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
RTN TO OWN ACFT	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000
THEATER SEARCH	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000
PART IN THEATER	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
PART TO AMC	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000
REQ FM CONUS	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000
BIT APPLIES	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
AVERAGE TIME 1	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094
PROBABILITY 8	0.3000	0.2829	0.2858	0.2886	0.2915	0.2943	0.2972	0.3000

TABLE A-1 (Continued)

BIT Cannot Locate

EVENT/EXCURSION	PERFECT BIT	BASE	CANNOT LOC =5%	CANNOT LOC =4%	CANNOT LOC =3%	CANNOT LOC =2%	CANNOT LOC =1%	CANNOT LOC =0%
PROBABILITY 9	0.0510	0.0481	0.0486	0.0491	0.0495	0.0500	0.0505	0.0510
AVERAGE TIME 2	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
PROB HSC W/O PART	0.1400	0.1162	0.1174	0.1186	0.1197	0.1209	0.1221	0.1232
TIME HSC W/O PART	0.1820	0.1511	0.1526	0.1541	0.1556	0.1572	0.1587	0.1602
PROOF PROB	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
FLYING HOURS	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000
MTBEMA	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000
ELAPSED HOURS	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000
ACFT ASSIGNED	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000

TABLE A-2

Isolation Error

EVENT/EXCURSION	PERFECT BIT	BASE	ISOLAT ERR =2.5%	ISOLAT ERR =2%	ISOLAT ERR =1.5%	ISOLAT ERR =1%	ISOLAT ERR =.5%	ISOLAT ERR =0%
CAN ISOLATE	1.0000	0.9400	0.9400	0.9400	0.9400	0.9400	0.9400	0.9400
HARDWARE OK	1.0000	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
INDICATES GO	1.0000	0.9200	0.9250	0.9300	0.9350	0.9400	0.9450	0.9500
DEPOT TRANS TIME	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000
DEPOT MAINT	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500
PROBABILITY OF DEPOT	.0000	0.1699	0.1656	0.1614	0.1571	0.1529	0.1486	0.1443
TOTAL DEPOT TRANS	.0000	1.9191	1.8639	1.8088	1.7536	1.6985	1.6433	1.5881
TOTAL DEPOT MAINT	.0000	0.5916	0.5760	0.5605	0.5450	0.5294	0.5139	0.4984
TOTAL DEPOT TIME	.0000	2.5106	2.4399	2.3693	2.2986	2.2279	2.1572	2.0865
MTTR	0.5000	0.5795	0.5768	0.5741	0.5714	0.5686	0.5659	0.5632
AVERAGE DOWN TIME	5.5149	7.0886	7.0414	6.9942	6.9470	6.8997	6.8525	6.8053
AVAILABILITY	68.1682	59.0844	59.3570	59.6295	59.9021	60.1747	60.4472	60.7198
PROB DEPOT 1	.0000	0.0570	0.0570	0.0570	0.0570	0.0570	0.0570	0.0570
TRANS DEPOT 1	.0000	0.4560	0.4560	0.4560	0.4560	0.4560	0.4560	0.4560
MAINT DEPOT 1	.0000	0.1796	0.1796	0.1796	0.1796	0.1796	0.1796	0.1796
TOTAL DEPOT 1	.0000	0.6356	0.6356	0.6356	0.6356	0.6356	0.6356	0.6356
PROB DEPOT 2	.0000	0.0401	0.0376	0.0351	0.0326	0.0301	0.0276	0.0251
TRANS DEPOT 2	.0000	0.3211	0.3010	0.2809	0.2609	0.2408	0.2207	0.2007
MAINT DEPOT 2	.0000	0.1465	0.1373	0.1282	0.1190	0.1099	0.1007	0.0916
TOTAL DEPOT 2	.0000	0.4676	0.4383	0.4091	0.3799	0.3507	0.3214	0.2922
PROB DEPOT 3	.0000	0.0231	0.0232	0.0233	0.0235	0.0236	0.0237	0.0238
TRANS DEPOT 3	.0000	0.1846	0.1856	0.1866	0.1876	0.1886	0.1896	0.1906
MAINT DEPOT3	.0000	0.0842	0.0847	0.0851	0.0856	0.0861	0.0865	0.0870

TABLE A-2 (Continued)

Isolation Error

EVENT/EXCURSION	PERFECT BIT	BASE	ISOLAT ERR =2.5%	ISOLAT ERR =2%	ISOLAT ERR =1.5%	ISOLAT ERR =1%	ISOLAT ERR =.5%	ISOLAT ERR =0%
TOTAL DEPOT 3	.0000	0.2688	0.2703	0.2718	0.2732	0.2747	0.2762	0.2776
PROB DEPOT 4	.0000	0.0100	0.0094	0.0088	0.0082	0.0075	0.0069	0.0063
TRANS DEPOT 4	.0000	0.0853	0.0800	0.0746	0.0693	0.0640	0.0586	0.0533
MAINT DEPOT 4	.0000	0.0366	0.0343	0.0320	0.0298	0.0275	0.0252	0.0229
TOTAL DEPOT 4	.0000	0.1219	0.1143	0.1067	0.0990	0.0914	0.0838	0.0762
PROB DEPOT 5	.0000	0.0058	0.0058	0.0058	0.0059	0.0059	0.0059	0.0060
TRANS DEPOT 5	.0000	0.0490	0.0493	0.0496	0.0498	0.0501	0.0504	0.0506
MAINT DEPOT 5	.0000	0.0211	0.0212	0.0213	0.0214	0.0215	0.0216	0.0217
TOTAL DEPOT 5	.0000	0.0701	0.0705	0.0709	0.0712	0.0716	0.0720	0.0724
PROB DEPOT 6	.0000	0.0056	0.0052	0.0049	0.0045	0.0042	0.0038	0.0035
TRANS DEPOT 6	.0000	0.0534	0.0501	0.0467	0.0434	0.0400	0.0367	0.0334
MAINT DEPOT 6	.0000	0.0203	0.0190	0.0177	0.0165	0.0152	0.0139	0.0127
TOTAL DEPOT 6	.0000	0.0737	0.0691	0.0645	0.0599	0.0552	0.0506	0.0460
PROB DEPOT 7	.0000	0.0032	0.0032	0.0032	0.0032	0.0033	0.0033	0.0033
TRANS DEPOT 7	.0000	0.0307	0.0309	0.0310	0.0312	0.0314	0.0315	0.0317
MAINT DEPOT 7	.0000	0.0117	0.0117	0.0118	0.0119	0.0119	0.0120	0.0120
TOTAL DEPOT 7	.0000	0.0424	0.0426	0.0428	0.0430	0.0433	0.0435	0.0437
PROB DEPOT 8	.0000	0.0146	0.0137	0.0128	0.0119	0.0110	0.0101	0.0091
TRANS DEPOT 8	.0000	0.1360	0.1275	0.1190	0.1105	0.1020	0.0935	0.0850
MAINT DEPOT8	.0000	0.0534	0.0500	0.0467	0.0434	0.0400	0.0367	0.0334
TOTAL DEPOT 8	.0000	0.1893	0.1775	0.1657	0.1538	0.1420	0.1302	0.1183
PROB DEPOT 9	.0000	0.0084	0.0085	0.0085	0.0085	0.0086	0.0086	0.0087
TRANS DEPOT 9	.0000	0.0782	0.0786	0.0790	0.0795	0.0799	0.0803	0.0807

TABLE A-2 (Continued)

Isolation Error

EVENT/EXCURSION	PERFECT BIT	BASE	ISOLAT ERR =2.5%	ISOLAT ERR =2%	ISOLAT ERR =1.5%	ISOLAT ERR =1%	ISOLAT ERR =.5%	ISOLAT ERR =0%
MAINT DEPOT 9	.0000	0.0307	0.0309	0.0310	0.0312	0.0314	0.0315	0.0317
TOTAL DEPOT 9	.0000	0.1089	0.1095	0.1100	0.1106	0.1112	0.1118	0.1124
PROB DEPOT 10	.0000	0.0010	0.0009	0.0008	0.0008	0.0007	0.0007	0.0006
TRANS DEPOT 10	.0000	0.1236	0.1159	0.1081	0.1004	0.0927	0.0850	0.0772
MAINT DEPOT 10	.0000	0.0035	0.0033	0.0030	0.0028	0.0026	0.0024	0.0022
TOTAL DEPOT 10	.0000	0.1271	0.1191	0.1112	0.1032	0.0953	0.0874	0.0794
PROB DEPOT 11	.0000	0.0005	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006
TRANS DEPOT 11	.0000	0.0711	0.0715	0.0718	0.0722	0.0726	0.0730	0.0734
MAINT DEPOT 11	.0000	0.0020	0.0020	0.0020	0.0020	0.0020	0.0021	0.0021
TOTAL DEPOT 11	.0000	0.0731	0.0735	0.0739	0.0743	0.0747	0.0751	0.0755
PROB DEPOT 12	.0000	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001
TRANS DEPOT 12	.0000	0.2083	0.1952	0.1822	0.1692	0.1562	0.1432	0.1302
MAINT DEPOT 12	.0000	0.0009	0.0008	0.0008	0.0007	0.0007	0.0006	0.0005
TOTAL DEPOT 12	.0000	0.2091	0.1961	0.1830	0.1699	0.1569	0.1438	0.1307
PROB DEPOT 13	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TRANS DEPOT 13	.0000	0.1198	0.1204	0.1211	0.1217	0.1224	0.1230	0.1237
MAINT DEPOT 13	.0000	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
TOTAL DEPOT 13	.0000	0.1203	0.1209	0.1216	0.1222	0.1229	0.1235	0.1242
PROB DEPOT 14	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TRANS DEPOT 14	.0000	0.0014	0.0013	0.0012	0.0011	0.0010	0.0009	0.0009
MAINT DEPOT 14	.0000	0.0005	0.0005	0.0004	0.0004	0.0004	0.0003	0.0003
TOTAL DEPOT 14	.0000	0.0018	0.0017	0.0016	0.0015	0.0014	0.0013	0.0012
PROB DEPOT 15	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

TABLE A-2 (Continued)

Isolation Error

EVENT/EXCURSION	PERFECT BIT	BASE	ISOLAT ERR =2.5%	ISOLAT ERR =2%	ISOLAT ERR =1.5%	ISOLAT ERR =1%	ISOLAT ERR =.5%	ISOLAT ERR =0%
TRANS DEPOT 15	.0000	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
MAINT DEPOT 15	.0000	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
TOTAL DEPOT 15	.0000	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
PROB FLT LN REPAIR	0.5600	0.4649	0.4673	0.4696	0.4720	0.4744	0.4768	0.4792
TIME FLT LN RPR	0.2800	0.2324	0.2336	0.2348	0.2360	0.2372	0.2384	0.2396
PROB PART FROM PLL	0.2040	0.1693	0.1702	0.1711	0.1719	0.1728	0.1737	0.1746
TIME PART FROM PLL	0.4284	0.3556	0.3574	0.3593	0.3611	0.3629	0.3647	0.3666
PROB PART FROM ASL	0.0775	0.0644	0.0647	0.0650	0.0653	0.0657	0.0660	0.0663
TIME PART FROM ASL	0.1868	0.1550	0.1558	0.1566	0.1574	0.1582	0.1590	0.1598
PROB PART FROM THEAT	0.0133	0.0110	0.0111	0.0112	0.0112	0.0113	0.0113	0.0114
TIME PART FROM THEAT	1.6287	1.3520	1.3590	1.3659	1.3728	1.3798	1.3867	1.3936
PROB PART FROM CONUS	0.0033	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
TIME PART FROM CONUS	2.8032	2.3270	2.3389	2.3508	2.3628	2.3747	2.3866	2.3986
PROB CONTROL SUB	0.0018	0.0015	0.0015	0.0015	0.0016	0.0016	0.0016	0.0016
TIME CONTROL SUB	0.0057	0.0048	0.0048	0.0048	0.0048	0.0049	0.0049	0.0049
PROB 1	1.0000	0.9430	0.9430	0.9430	0.9430	0.9430	0.9430	0.9430
PROB 2	0.1400	0.1320	0.1320	0.1320	0.1320	0.1320	0.1320	0.1320
PROB 3	.0000	0.0760	0.0712	0.0665	0.0617	0.0570	0.0523	0.0475
PROB 4	.0000	0.0437	0.0439	0.0442	0.0444	0.0447	0.0449	0.0451
PROB 5	1.0000	0.8803	0.8848	0.8893	0.8938	0.8984	0.9029	0.9074
PROB 6	0.0960	0.0905	0.0905	0.0905	0.0905	0.0905	0.0905	0.0905
PROB 7	0.0185	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174
BIT APPLIES	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500

TABLE A-2 (Continued)

Isolation Error

EVENT/EXCURSION	PERFECT BIT	BASE	ISOLAT ERR =2.5%	ISOLAT ERR =2%	ISOLAT ERR =1.5%	ISOLAT ERR =1%	ISOLAT ERR =.5%	ISOLAT ERR =0%
FLT LN REPAIR	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
NEED PART	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
MAINT ACTION	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
GO TO MSC	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
RETURN TO FLT LN	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
PART ON PLL	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
GO TO AMC	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
PART ON ASL	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
IN STK ASL	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
RTN TO ACFT	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
GO TO PLL STOCK	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
IN STK PLL	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
CONTROL SUB	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
GO TO ACFT	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
REMOVE PART	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
RTN TO OWN ACFT	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000
THEATER SEARCH	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000
PART IN THEATER	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
PART TO AMC	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000
REQ FM CONUS	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000
BIT APPLIES	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
AVERAGE TIME 1	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094
PROBABILITY 8	0.3000	0.2829	0.2829	0.2829	0.2829	0.2829	0.2829	0.2829

TABLE A-2 (Continued)

Isolation Error

EVENT/EXCURSION	PERFECT BIT	BASE	ISOLAT ERR =2.5%	ISOLAT ERR =2%	ISOLAT ERR =1.5%	ISOLAT ERR =1%	ISOLAT ERR =.5%	ISOLAT ERR =0%
PROBABILITY 9	0.0510	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481
AVERAGE TIME 2	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
PROB HSC W/O PART	0.1400	0.1162	0.1168	0.1174	0.1180	0.1186	0.1192	0.1198
TIME HSC W/O PART	0.1820	0.1511	0.1519	0.1526	0.1534	0.1542	0.1550	0.1557
PROOF PROB	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
FLYING HOURS	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000
MTBEMA	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000
ELAPSED HOURS	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000
ACFT ASSIGNED	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000

TABLE A-3

False Indication

EVENT/EXCURSION	PERFECT BIT	BASE	FALSE IND =4%	FALSE IND =3%	FALSE IND =2%	FALSE IND =1%	FALSE IND =0%
CAN ISOLATE	1.0000	0.9400	0.9400	0.9400	0.9400	0.9400	0.9400
HARDWARE OK	1.0000	0.9500	0.9600	0.9700	0.9800	0.9900	1.0000
INDICATES GO	1.0000	0.9200	0.9300	0.9400	0.9500	0.9600	0.9700
DEPOT TRANS TIME	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000
DEPOT MAINT	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500
PROBABILITY OF DEPOT	.0000	0.1699	0.1530	0.1360	0.1188	0.1014	0.0839
TOTAL DEPOT TRANS	.0000	1.9191	1.7008	1.4802	1.2572	1.0319	0.8044
TOTAL DEPOT MAINT	.0000	0.5916	0.5301	0.4680	0.4052	0.3417	0.2776
TOTAL DEPOT TIME	.0000	2.5106	2.2309	1.9481	1.6624	1.3737	1.0820
MTTR	0.5000	0.5795	0.5688	0.5579	0.5470	0.5360	0.5248
AVERAGE DOWN TIME	5.5149	7.0886	6.9017	6.7128	6.5220	6.3291	6.1343
AVAILABILITY	68.1682	59.0844	60.1632	61.2534	62.3551	63.4683	64.5929
PROB DEPOT 1	.0000	0.0570	0.0570	0.0570	0.0570	0.0570	0.0570
TRANS DEPOT 1	.0000	0.4560	0.4560	0.4560	0.4560	0.4560	0.4560
MAINT DEPOT 1	.0000	0.1796	0.1796	0.1796	0.1796	0.1796	0.1796
TOTAL DEPOT 1	.0000	0.6356	0.6356	0.6356	0.6356	0.6356	0.6356
PROB DEPOT 2	.0000	0.0401	0.0351	0.0301	0.0251	0.0201	0.0151
TRANS DEPOT 2	.0000	0.3211	0.2809	0.2408	0.2007	0.1605	0.1204
MAINT DEPOT 2	.0000	0.1465	0.1282	0.1099	0.0916	0.0732	0.0549
TOTAL DEPOT 2	.0000	0.4676	0.4091	0.3507	0.2922	0.2338	0.1753
PROB DEPOT 3	.0000	0.0231	0.0187	0.0141	0.0095	0.0048	.0000
TRANS DEPOT 3	.0000	0.1846	0.1493	0.1132	0.0763	0.0385	.0000
MAINT DEPOT3	.0000	0.0842	0.0681	0.0516	0.0348	0.0176	.0000

TABLE A-3 (Continued)

False Indication

EVENT/EXCURSION	PERFECT BIT	BASE	FALSE IND =4%	FALSE IND =3%	FALSE IND =2%	FALSE IND =1%	FALSE IND =0%
TOTAL DEPOT 3	.0000	0.2688	0.2174	0.1648	0.1110	0.0561	.0000
PROB DEPOT 4	.0000	0.0100	0.0088	0.0075	0.0063	0.0050	0.0038
TRANS DEPOT 4	.0000	0.0853	0.0746	0.0640	0.0533	0.0426	0.0320
MAINT DEPOT 4	.0000	0.0366	0.0320	0.0275	0.0229	0.0183	0.0137
TOTAL DEPOT 4	.0000	0.1219	0.1067	0.0914	0.0762	0.0610	0.0457
PROB DEPOT 5	.0000	0.0058	0.0047	0.0035	0.0024	0.0012	.0000
TRANS DEPOT 5	.0000	0.0490	0.0397	0.0301	0.0203	0.0102	.0000
MAINT DEPOT 5	.0000	0.0211	0.0170	0.0129	0.0087	0.0044	.0000
TOTAL DEPOT 5	.0000	0.0701	0.0567	0.0430	0.0290	0.0146	.0000
PROB DEPOT 6	.0000	0.0056	0.0049	0.0042	0.0035	0.0028	0.0021
TRANS DEPOT 6	.0000	0.0534	0.0467	0.0400	0.0334	0.0267	0.0200
MAINT DEPOT 6	.0000	0.0203	0.0177	0.0152	0.0127	0.0101	0.0076
TOTAL DEPOT 6	.0000	0.0737	0.0645	0.0552	0.0460	0.0368	0.0276
PROB DEPOT 7	.0000	0.0032	0.0026	0.0020	0.0013	0.0007	.0000
TRANS DEPOT 7	.0000	0.0307	0.0248	0.0188	0.0127	0.0064	.0000
MAINT DEPOT 7	.0000	0.0117	0.0094	0.0071	0.0048	0.0024	.0000
TOTAL DEPOT 7	.0000	0.0424	0.0343	0.0260	0.0175	0.0088	.0000
PROB DEPOT 8	.0000	0.0146	0.0128	0.0110	0.0091	0.0073	0.0055
TRANS DEPOT 8	.0000	0.1360	0.1190	0.1020	0.0850	0.0680	0.0510
MAINT DEPOT8	.0000	0.0534	0.0467	0.0400	0.0334	0.0267	0.0200
TOTAL DEPOT 8	.0000	0.1893	0.1657	0.1420	0.1183	0.0947	0.0710
PROB DEPOT 9	.0000	0.0084	0.0068	0.0052	0.0035	0.0018	.0000
TRANS DEPOT 9	.0000	0.0782	0.0632	0.0479	0.0323	0.0163	.0000

TABLE A-3 (Continued)

False Indication

EVENT/EXCURSION	PERFECT BIT	BASE	FALSE IND =4%	FALSE IND =3%	FALSE IND =2%	FALSE IND =1%	FALSE IND =0%
MAINT DEPOT 9	.0000	0.0307	0.0248	0.0188	0.0127	0.0064	.0000
TOTAL DEPOT 9	.0000	0.1089	0.0880	0.0667	0.0450	0.0227	.0000
PROB DEPOT 10	.0000	0.0010	0.0008	0.0007	0.0006	0.0005	0.0004
TRANS DEPOT 10	.0000	0.1236	0.1081	0.0927	0.0772	0.0618	0.0463
MAINT DEPOT 10	.0000	0.0035	0.0030	0.0026	0.0022	0.0017	0.0013
TOTAL DEPOT 10	.0000	0.1271	0.1112	0.0953	0.0794	0.0635	0.0477
PROB DEPOT 11	.0000	0.0005	0.0004	0.0003	0.0002	0.0001	.0000
TRANS DEPOT 11	.0000	0.0711	0.0575	0.0436	0.0294	0.0148	.0000
MAINT DEPOT 11	.0000	0.0020	0.0016	0.0012	0.0008	0.0004	.0000
TOTAL DEPOT 11	.0000	0.0731	0.0591	0.0448	0.0302	0.0152	.0000
PROB DEPOT 12	.0000	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001
TRANS DEPOT 12	.0000	0.2083	0.1822	0.1562	0.1302	0.1041	0.0781
MAINT DEPOT 12	.0000	0.0009	0.0008	0.0007	0.0005	0.0004	0.0003
TOTAL DEPOT 12	.0000	0.2091	0.1830	0.1569	0.1307	0.1046	0.0784
PROB DEPOT 13	.0000	0.0001	0.0001	0.0001	0.0001	.0000	.0000
TRANS DEPOT 13	.0000	0.1198	0.0968	0.0734	0.0495	0.0250	.0000
MAINT DEPOT 13	.0000	0.0005	0.0004	0.0003	0.0002	0.0001	.0000
TOTAL DEPOT 13	.0000	0.1203	0.0972	0.0737	0.0497	0.0251	.0000
PROB DEPOT 14	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	.0000
TRANS DEPOT 14	.0000	0.0014	0.0012	0.0010	0.0009	0.0007	0.0005
MAINT DEPOT 14	.0000	0.0005	0.0004	0.0004	0.0003	0.0002	0.0002
TOTAL DEPOT 14	.0000	0.0018	0.0016	0.0014	0.0012	0.0009	0.0007
PROB DEPOT 15	.0000	0.0001	0.0001	.0000	.0000	.0000	.0000

TABLE A-3 (Continued)

False Indication

EVENT/EXCURSION	PERFECT BIT	BASE	FALSE IND =4%	FALSE IND =3%	FALSE IND =2%	FALSE IND =1%	FALSE IND =0%
TRANS DEPOT 15	.0000	0.0008	0.0006	0.0005	0.0003	0.0002	.0000
MAINT DEPOT 15	.0000	0.0003	0.0002	0.0002	0.0001	0.0001	.0000
TOTAL DEPOT 15	.0000	0.0011	0.0009	0.0007	0.0004	0.0002	.0000
PROB FLT LN REPAIR	0.5600	0.4649	0.4743	0.4838	0.4935	0.5032	0.5130
TIME FLT LN RPR	0.2800	0.2324	0.2372	0.2419	0.2467	0.2516	0.2565
PROB PART FROM PLL	0.2040	0.1693	0.1728	0.1763	0.1798	0.1833	0.1869
TIME PART FROM PLL	0.4284	0.3556	0.3628	0.3701	0.3775	0.3849	0.3925
PROB PART FROM ASL	0.0775	0.0644	0.0657	0.0670	0.0683	0.0697	0.0710
TIME PART FROM ASL	0.1868	0.1550	0.1582	0.1614	0.1646	0.1678	0.1711
PROB PART FROM THEAT	0.0133	0.0110	0.0113	0.0115	0.0117	0.0120	0.0122
TIME PART FROM THEAT	1.6287	1.3520	1.3795	1.4072	1.4352	1.4635	1.4921
PROB PART FROM CONUS	0.0033	0.0028	0.0028	0.0029	0.0029	0.0030	0.0030
TIME PART FROM CONUS	2.8032	2.3270	2.3742	2.4219	2.4701	2.5188	2.5681
PROB CONTROL SUB	0.0018	0.0015	0.0016	0.0016	0.0016	0.0017	0.0017
TIME CONTROL SUB	0.0057	0.0048	0.0049	0.0050	0.0051	0.0052	0.0053
PROB 1	1.0000	0.9430	0.9430	0.9430	0.9430	0.9430	0.9430
PROB 2	0.1400	0.1320	0.1320	0.1320	0.1320	0.1320	0.1320
PROB 3	.0000	0.0760	0.0665	0.0570	0.0475	0.0380	0.0285
PROB 4	.0000	0.0437	0.0353	0.0268	0.0181	0.0091	.0000
PROB 5	1.0000	0.8803	0.8982	0.9162	0.9345	0.9529	0.9715
PROB 6	0.0960	0.0905	0.0905	0.0905	0.0905	0.0905	0.0905
PROB 7	0.0185	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174
BIT APPLIES	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500

TABLE A-3 (Continued)

False Indication

EVENT/EXCURSION	PERFECT BIT	BASE	FALSE IND =4%	FALSE IND =3%	FALSE IND =2%	FALSE IND =1%	FALSE IND =0%
FLT LN REPAIR	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
NEED PART	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
MAINT ACTION	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
GO TO MSC	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
RETURN TO FLT LN	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
PART ON PLL	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
GO TO AMC	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
PART ON ASL	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
IN STK ASL	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
RTN TO ACFT	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
GO TO PLL STOCK	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
IN STK PLL	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
CONTROL SUB	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
GO TO ACFT	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
REMOVE PART	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
RTN TO OWN ACFT	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000
THEATER SEARCH	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000
PART IN THEATER	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
PART TO AMC	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000
REQ FM CONUS	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000
BIT APPLIES	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
AVERAGE TIME 1	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094
PROBABILITY 8	0.3000	0.2829	0.2829	0.2829	0.2829	0.2829	0.2829

TABLE A-3 (Continued)

False Indication

EVENT/EXCURSION	PERFECT BIT	BASE	FALSE IND =4%	FALSE IND =3%	FALSE IND =2%	FALSE IND =1%	FALSE IND =0%
PROBABILITY 9	0.0510	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481
AVERAGE TIME 2	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
PROB HSC W/O PART	0.1400	0.1162	0.1186	0.1210	0.1234	0.1258	0.1283
TIME HSC W/O PART	0.1820	0.1511	0.1541	0.1572	0.1604	0.1635	0.1667
PROOF PROB	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
FLYING HOURS	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000
MTBEMA	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000
ELAPSED HOURS	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000
ACFT ASSIGNED	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000

TABLE A-4

Depot Maintenance Time

EVENT/EXCURSION	PERFECT BIT	BASE	DEPOT MAINT=3	DEPOT MAINT=2.5	DEPOT MAINT=2	DEPOT MAINT=1.5	DEPOT MAINT=1	DEPOT MAINT=.5
CAN ISOLATE	1.0000	0.9400	0.9400	0.9400	0.9400	0.9400	0.9400	0.9400
HARDWARE OK	1.0000	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
INDICATES GO	1.0000	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200
DEPOT TRANS TIME	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000	8.0000
DEPOT MAINT	3.1500	3.1500	3.0000	2.5000	2.0000	1.5000	1.0000	0.5000
PROB OF DEPOT	.0000	0.1699	0.1699	0.1699	0.1699	0.1699	0.1699	0.1699
TOTAL DEPOT TRAN	.0000	1.9191	1.9191	1.9191	1.9191	1.9191	1.9191	1.9191
TOTAL DEPOT MAIN	.0000	0.5916	0.5661	0.4811	0.3962	0.3113	0.2263	0.1414
TOTAL DEPOT TIME	.0000	2.5106	2.4851	2.4002	2.3153	2.2303	2.1454	2.0605
MTTR	0.5000	0.5795	0.5780	0.5732	0.5683	0.5635	0.5586	0.5538
AVERAGE DOWN TIM	5.5149	7.0886	7.0631	6.9782	6.8933	6.8083	6.7234	6.6384
AVAILABILITY	68.1682	59.0844	59.2315	59.7218	60.2120	60.7023	61.1926	61.6828
PROB DEPOT 1	.0000	0.0570	0.0570	0.0570	0.0570	0.0570	0.0570	0.0570
TRANS DEPOT 1	.0000	0.4560	0.4560	0.4560	0.4560	0.4560	0.4560	0.4560
MAINT DEPOT 1	.0000	0.1796	0.1710	0.1425	0.1140	0.0855	0.0570	0.0285
TOTAL DEPOT 1	.0000	0.6356	0.6270	0.5985	0.5700	0.5415	0.5130	0.4845
PROB DEPOT 2	.0000	0.0401	0.0401	0.0401	0.0401	0.0401	0.0401	0.0401
TRANS DEPOT 2	.0000	0.3211	0.3211	0.3211	0.3211	0.3211	0.3211	0.3211
MAINT DEPOT 2	.0000	0.1465	0.1405	0.1204	0.1003	0.0803	0.0602	0.0401
TOTAL DEPOT 2	.0000	0.4676	0.4615	0.4415	0.4214	0.4013	0.3813	0.3612
PROB DEPOT 3	.0000	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
TRANS DEPOT 3	.0000	0.1846	0.1846	0.1846	0.1846	0.1846	0.1846	0.1846
MAINT DEPOT3	.0000	0.0842	0.0808	0.0692	0.0577	0.0462	0.0346	0.0231

TABLE A-4 (Continued)

Depot Maintenance Time

EVENT/EXCURSION	PERFECT BIT	BASE	DEPOT MAINT=3	DEPOT MAINT=2.5	DEPOT MAINT=2	DEPOT MAINT=1.5	DEPOT MAINT=1	DEPOT MAINT=.5
TOTAL DEPOT 3	.0000	0.2688	0.2654	0.2538	0.2423	0.2308	0.2192	0.2077
PROB DEPOT 4	.0000	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
TRANS DEPOT 4	.0000	0.0853	0.0853	0.0853	0.0853	0.0853	0.0853	0.0853
MAINT DEPOT 4	.0000	0.0366	0.0351	0.0301	0.0251	0.0201	0.0151	0.0100
TOTAL DEPOT 4	.0000	0.1219	0.1204	0.1154	0.1104	0.1054	0.1003	0.0953
PROB DEPOT 5	.0000	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058
TRANS DEPOT 5	.0000	0.0490	0.0490	0.0490	0.0490	0.0490	0.0490	0.0490
MAINT DEPOT 5	.0000	0.0211	0.0202	0.0173	0.0144	0.0115	0.0087	0.0058
TOTAL DEPOT 5	.0000	0.0701	0.0692	0.0663	0.0635	0.0606	0.0577	0.0548
PROB DEPOT 6	.0000	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056
TRANS DEPOT 6	.0000	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534
MAINT DEPOT 6	.0000	0.0203	0.0194	0.0167	0.0139	0.0111	0.0083	0.0056
TOTAL DEPOT 6	.0000	0.0737	0.0728	0.0701	0.0673	0.0645	0.0617	0.0589
PROB DEPOT 7	.0000	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032
TRANS DEPOT 7	.0000	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307
MAINT DEPOT 7	.0000	0.0117	0.0112	0.0096	0.0080	0.0064	0.0048	0.0032
TOTAL DEPOT 7	.0000	0.0424	0.0419	0.0403	0.0387	0.0371	0.0355	0.0339
PROB DEPOT 8	.0000	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146
TRANS DEPOT 8	.0000	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360	0.1360
MAINT DEPOT8	.0000	0.0534	0.0512	0.0439	0.0366	0.0292	0.0219	0.0146
TOTAL DEPOT 8	.0000	0.1893	0.1871	0.1798	0.1725	0.1652	0.1579	0.1506
PROB DEPOT 9	.0000	0.0084	0.0084	0.0084	0.0084	0.0084	0.0084	0.0084
TRANS DEPOT 9	.0000	0.0782	0.0782	0.0782	0.0782	0.0782	0.0782	0.0782

TABLE A-4 (Continued)

Depot Maintenance Time

EVENT/EXCURSION	PERFECT BIT	BASE	DEPOT MAINT=3	DEPOT MAINT=2.5	DEPOT MAINT=2	DEPOT MAINT=1.5	DEPOT MAINT=1	DEPOT MAINT=.5
MAINT DEPOT 9	.0000	0.0307	0.0294	0.0252	0.0210	0.0168	0.0126	0.0084
TOTAL DEPOT 9	.0000	0.1089	0.1076	0.1034	0.0992	0.0950	0.0908	0.0866
PROB DEPOT 10	.0000	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
TRANS DEPOT 10	.0000	0.1236	0.1236	0.1236	0.1236	0.1236	0.1236	0.1236
MAINT DEPOT 10	.0000	0.0035	0.0033	0.0029	0.0024	0.0019	0.0014	0.0010
TOTAL DEPOT 10	.0000	0.1271	0.1269	0.1265	0.1260	0.1255	0.1250	0.1245
PROB DEPOT 11	.0000	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
TRANS DEPOT 11	.0000	0.0711	0.0711	0.0711	0.0711	0.0711	0.0711	0.0711
MAINT DEPOT 11	.0000	0.0020	0.0019	0.0016	0.0014	0.0011	0.0008	0.0005
TOTAL DEPOT 11	.0000	0.0731	0.0730	0.0727	0.0724	0.0722	0.0719	0.0716
PROB DEPOT 12	.0000	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
TRANS DEPOT 12	.0000	0.2083	0.2083	0.2083	0.2083	0.2083	0.2083	0.2083
MAINT DEPOT 12	.0000	0.0009	0.0008	0.0007	0.0006	0.0005	0.0004	0.0002
TOTAL DEPOT 12	.0000	0.2091	0.2091	0.2090	0.2089	0.2087	0.2086	0.2085
PROB DEPOT 13	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TRANS DEPOT 13	.0000	0.1198	0.1198	0.1198	0.1198	0.1198	0.1198	0.1198
MAINT DEPOT 13	.0000	0.0005	0.0005	0.0004	0.0003	0.0003	0.0002	0.0001
TOTAL DEPOT 13	.0000	0.1203	0.1202	0.1202	0.1201	0.1200	0.1200	0.1199
PROB DEPOT 14	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TRANS DEPOT 14	.0000	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
MAINT DEPOT 14	.0000	0.0005	0.0005	0.0004	0.0003	0.0003	0.0002	0.0001
TOTAL DEPOT 14	.0000	0.0018	0.0018	0.0018	0.0017	0.0016	0.0016	0.0015
PROB DEPOT 15	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

TABLE A-4 (Continued)

Depot Maintenance Time

EVENT/EXCURSION	PERFECT BIT	BASE	DEPOT MAINT=3	DEPOT MAINT=2.5	DEPOT MAINT=2	DEPOT MAINT=1.5	DEPOT MAINT=1	DEPOT MAINT=.5
TRANS DEPOT 15	.0000	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
MAINT DEPOT 15	.0000	0.0003	0.0003	0.0002	0.0002	0.0002	0.0001	0.0001
TOTAL DEPOT 15	.0000	0.0011	0.0011	0.0010	0.0010	0.0009	0.0009	0.0009
PROB FLT LN REPA	0.5600	0.4649	0.4649	0.4649	0.4649	0.4649	0.4649	0.4649
TIME FLT LN RPR	0.2800	0.2324	0.2324	0.2324	0.2324	0.2324	0.2324	0.2324
PROB PART FROM P	0.2040	0.1693	0.1693	0.1693	0.1693	0.1693	0.1693	0.1693
TIME PART FROM P	0.4284	0.3556	0.3556	0.3556	0.3556	0.3556	0.3556	0.3556
PROB PART FROM A	0.0775	0.0644	0.0644	0.0644	0.0644	0.0644	0.0644	0.0644
TIME PART FROM A	0.1868	0.1550	0.1550	0.1550	0.1550	0.1550	0.1550	0.1550
PROB PART FROM T	0.0133	0.0110	0.0110	0.0110	0.0110	0.0110	0.0110	0.0110
TIME PART FROM T	1.6287	1.3520	1.3520	1.3520	1.3520	1.3520	1.3520	1.3520
PROB PART FROM C	0.0033	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
TIME PART FROM C	2.8032	2.3270	2.3270	2.3270	2.3270	2.3270	2.3270	2.3270
PROB CONTROL SUB	0.0018	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015
TIME CONTROL SUB	0.0057	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048
PROB 1	1.0000	0.9430	0.9430	0.9430	0.9430	0.9430	0.9430	0.9430
PROB 2	0.1400	0.1320	0.1320	0.1320	0.1320	0.1320	0.1320	0.1320
PROB 3	.0000	0.0760	0.0760	0.0760	0.0760	0.0760	0.0760	0.0760
PROB 4	.0000	0.0437	0.0437	0.0437	0.0437	0.0437	0.0437	0.0437
PROB 5	1.0000	0.8803	0.8803	0.8803	0.8803	0.8803	0.8803	0.8803
PROB 6	0.0960	0.0905	0.0905	0.0905	0.0905	0.0905	0.0905	0.0905
PROB 7	0.0185	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174
BIT APPLIES	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500

TABLE A-4 (Continued)

Depot Maintenance Time

EVENT/EXCURSION	PERFECT BIT	BASE	DEPOT MAINT=3	DEPOT MAINT=2.5	DEPOT MAINT=2	DEPOT MAINT=1.5	DEPOT MAINT=1	DEPOT MAINT=.5
FLT LN REPAIR	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
NEED PART	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
MAINT ACTION	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
GO TO MSC	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
RETURN TO FLT LN	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
PART ON PLL	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
GO TO AMC	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
PART ON ASL	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
IN STK ASL	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
RTN TO ACFT	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
GO TO PLL STOCK	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
IN STK PLL	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
CONTROL SUB	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
GO TO ACFT	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
REMOVE PART	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
RTN TO OWN ACFT	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000
THEATER SEARCH	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000
PART IN THEATER	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
PART TO AMC	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000
REQ FM CONUS	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000
BIT APPLIES	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
AVERAGE TIME 1	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094
PROBABILITY 8	0.3000	0.2829	0.2829	0.2829	0.2829	0.2829	0.2829	0.2829

TABLE A-4 (Continued)

Depot Maintenance Time

EVENT/EXCURSION	PERFECT BIT	BASE	DEPOT MAINT=3	DEPOT MAINT=2.5	DEPOT MAINT=2	DEPOT MAINT=1.5	DEPOT MAINT=1	DEPOT MAINT=.5
PROBABILITY 9	0.0510	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481
AVERAGE TIME 2	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
PROB NSC W/O PAR	0.1400	0.1162	0.1162	0.1162	0.1162	0.1162	0.1162	0.1162
TIME NSC W/O PAR	0.1820	0.1511	0.1511	0.1511	0.1511	0.1511	0.1511	0.1511
PROOF PROB	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
FLYING HOURS	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000
MTBEMA	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000
ELAPSED HOURS	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000
ACFT ASSIGNED	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000

TABLE A-5

Depot Transit Time

EVENT/EXCURSION	PERFECT BIT	BASE	DEPOT TRANS =7	DEPOT TRANS =6	DEPOT TRANS =5	DEPOT TRANS =4	DEPOT TRANS =3	DEPOT TRANS =2	DEPOT TRANS =1	DEPOT TRANS =0
CAN ISOLATE	1.0000	0.9400	0.9400	0.9400	0.9400	0.9400	0.9400	0.9400	0.9400	0.9400
HARDWARE OK	1.0000	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
INDICATES GO	1.0000	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200	0.9200
DEPOT TRANS TIME	8.0000	8.0000	7.0000	6.0000	5.0000	4.0000	3.0000	2.0000	1.0000	0.0000
DEPOT MAINT	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500	3.1500
PROBABILITY OF DEPOT	.0000	0.1699	0.1699	0.1699	0.1699	0.1699	0.1699	0.1699	0.1699	0.1699
TOTAL DEPOT TRANS	.0000	1.9191	1.7492	1.5793	1.4094	1.2396	1.0697	0.8998	0.7299	0.5601
TOTAL DEPOT MAINT	.0000	0.5916	0.5916	0.5916	0.5916	0.5916	0.5916	0.5916	0.5916	0.5916
TOTAL DEPOT TIME	.0000	2.5106	2.3408	2.1709	2.0010	1.8311	1.6612	1.4914	1.3215	1.1516
MTTR	0.5000	0.5795	0.5698	0.5601	0.5504	0.5407	0.5311	0.5214	0.5117	0.5020
AVERAGE DOWN TIME	5.5149	7.0886	6.9187	6.7489	6.5790	6.4091	6.2392	6.0694	5.8995	5.7296
AVAILABILITY	68.1682	59.0844	60.0650	61.0455	62.0260	63.0066	63.9871	64.9676	65.9482	66.9287
PROB DEPOT 1	.0000	0.0570	0.0570	0.0570	0.0570	0.0570	0.0570	0.0570	0.0570	0.0570
TRANS DEPOT 1	.0000	0.4560	0.3990	0.3420	0.2850	0.2280	0.1710	0.1140	0.0570	0.0000
MAINT DEPOT 1	.0000	0.1796	0.1796	0.1796	0.1796	0.1796	0.1796	0.1796	0.1796	0.1796
TOTAL DEPOT 1	.0000	0.6356	0.5786	0.5216	0.4646	0.4076	0.3506	0.2936	0.2366	0.1796
PROB DEPOT 2	.0000	0.0401	0.0401	0.0401	0.0401	0.0401	0.0401	0.0401	0.0401	0.0401
TRANS DEPOT 2	.0000	0.3211	0.2809	0.2408	0.2007	0.1605	0.1204	0.0803	0.0401	0.0000
MAINT DEPOT 2	.0000	0.1465	0.1465	0.1465	0.1465	0.1465	0.1465	0.1465	0.1465	0.1465
TOTAL DEPOT 2	.0000	0.4676	0.4274	0.3873	0.3472	0.3070	0.2669	0.2268	0.1866	0.1465
PROB DEPOT 3	.0000	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231	0.0231
TRANS DEPOT 3	.0000	0.1846	0.1615	0.1385	0.1154	0.0923	0.0692	0.0462	0.0231	0.0000
MAINT DEPOT3	.0000	0.0842	0.0842	0.0842	0.0842	0.0842	0.0842	0.0842	0.0842	0.0842

TABLE A-5 (Continued)

Depot Transit Time

EVENT/EXCURSION	PERFECT BIT	BASE	DEPOT TRANS =7	DEPOT TRANS =6	DEPOT TRANS =5	DEPOT TRANS =4	DEPOT TRANS =3	DEPOT TRANS =2	DEPOT TRANS =1	DEPOT TRANS =0
TOTAL DEPOT 3	.0000	0.2688	0.2458	0.2227	0.1996	0.1765	0.1535	0.1304	0.1073	0.0842
PROB DEPOT 4	.0000	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100
TRANS DEPOT 4	.0000	0.0853	0.0753	0.0652	0.0552	0.0452	0.0351	0.0251	0.0151	0.0050
MAINT DEPOT 4	.0000	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366	0.0366
TOTAL DEPOT 4	.0000	0.1219	0.1119	0.1018	0.0918	0.0818	0.0717	0.0617	0.0517	0.0416
PROB DEPOT 5	.0000	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058	0.0058
TRANS DEPOT 5	.0000	0.0490	0.0433	0.0375	0.0317	0.0260	0.0202	0.0144	0.0087	0.0029
MAINT DEPOT 5	.0000	0.0211	0.0211	0.0211	0.0211	0.0211	0.0211	0.0211	0.0211	0.0211
TOTAL DEPOT 5	.0000	0.0701	0.0643	0.0586	0.0528	0.0470	0.0413	0.0355	0.0297	0.0239
PROB DEPOT 6	.0000	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056
TRANS DEPOT 6	.0000	0.0534	0.0478	0.0423	0.0367	0.0312	0.0256	0.0201	0.0145	0.0089
MAINT DEPOT 6	.0000	0.0203	0.0203	0.0203	0.0203	0.0203	0.0203	0.0203	0.0203	0.0203
TOTAL DEPOT 6	.0000	0.0737	0.0681	0.0626	0.0570	0.0514	0.0459	0.0403	0.0348	0.0292
PROB DEPOT 7	.0000	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032
TRANS DEPOT 7	.0000	0.0307	0.0275	0.0243	0.0211	0.0179	0.0147	0.0115	0.0083	0.0051
MAINT DEPOT 7	.0000	0.0117	0.0117	0.0117	0.0117	0.0117	0.0117	0.0117	0.0117	0.0117
TOTAL DEPOT 7	.0000	0.0424	0.0392	0.0360	0.0328	0.0296	0.0264	0.0232	0.0200	0.0168
PROB DEPOT 8	.0000	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146
TRANS DEPOT 8	.0000	0.1360	0.1213	0.1067	0.0921	0.0775	0.0629	0.0482	0.0336	0.0190
MAINT DEPOT8	.0000	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534	0.0534
TOTAL DEPOT 8	.0000	0.1893	0.1747	0.1601	0.1455	0.1309	0.1162	0.1016	0.0870	0.0724
PROB DEPOT 9	.0000	0.0084	0.0084	0.0084	0.0084	0.0084	0.0084	0.0084	0.0084	0.0084
TRANS DEPOT 9	.0000	0.0782	0.0698	0.0614	0.0530	0.0446	0.0361	0.0277	0.0193	0.0109

TABLE A-5 (Continued)

Depot Transit Time

EVENT/EXCURSION	PERFECT BIT	BASE	DEPOT TRANS =7	DEPOT TRANS =6	DEPOT TRANS =5	DEPOT TRANS =4	DEPOT TRANS =3	DEPOT TRANS =2	DEPOT TRANS =1	DEPOT TRANS =0
MAINT DEPOT 9	.0000	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307	0.0307
TOTAL DEPOT 9	.0000	0.1089	0.1005	0.0921	0.0836	0.0752	0.0668	0.0584	0.0500	0.0416
PROB DEPOT 10	.0000	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
TRANS DEPOT 10	.0000	0.1236	0.1226	0.1217	0.1207	0.1198	0.1188	0.1179	0.1169	0.1160
MAINT DEPOT 10	.0000	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035	0.0035
TOTAL DEPOT 10	.0000	0.1271	0.1261	0.1252	0.1242	0.1233	0.1223	0.1214	0.1204	0.1194
PROB DEPOT 11	.0000	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
TRANS DEPOT 11	.0000	0.0711	0.0705	0.0700	0.0694	0.0689	0.0683	0.0678	0.0672	0.0667
MAINT DEPOT 11	.0000	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
TOTAL DEPOT 11	.0000	0.0731	0.0725	0.0720	0.0714	0.0709	0.0703	0.0698	0.0692	0.0687
PROB DEPOT 12	.0000	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
TRANS DEPOT 12	.0000	0.2083	0.2080	0.2078	0.2076	0.2073	0.2071	0.2068	0.2066	0.2064
MAINT DEPOT 12	.0000	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
TOTAL DEPOT 12	.0000	0.2091	0.2089	0.2087	0.2084	0.2082	0.2079	0.2077	0.2075	0.2072
PROB DEPOT 13	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TRANS DEPOT 13	.0000	0.1198	0.1196	0.1195	0.1193	0.1192	0.1191	0.1189	0.1188	0.1187
MAINT DEPOT 13	.0000	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
TOTAL DEPOT 13	.0000	0.1203	0.1201	0.1200	0.1198	0.1197	0.1196	0.1194	0.1193	0.1192
PROB DEPOT 14	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TRANS DEPOT 14	.0000	0.0014	0.0012	0.0011	0.0010	0.0008	0.0007	0.0006	0.0004	0.0003
MAINT DEPOT 14	.0000	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
TOTAL DEPOT 14	.0000	0.0018	0.0017	0.0016	0.0015	0.0013	0.0012	0.0011	0.0009	0.0008
PROB DEPOT 15	.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

TABLE A-5 (Continued)

Depot Transit Time

EVENT/EXCURSION	PERFECT BIT	BASE	DEPOT TRANS =7	DEPOT TRANS =6	DEPOT TRANS =5	DEPOT TRANS =4	DEPOT TRANS =3	DEPOT TRANS =2	DEPOT TRANS =1	DEPOT TRANS =0
TRANS DEPOT 15	.0000	0.0008	0.0007	0.0006	0.0006	0.0005	0.0004	0.0003	0.0003	0.0002
MAINT DEPOT 15	.0000	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
TOTAL DEPOT 15	.0000	0.0011	0.0010	0.0009	0.0008	0.0008	0.0007	0.0006	0.0005	0.0005
PROB FLT LN REPAIR	0.5600	0.4649	0.4649	0.4649	0.4649	0.4649	0.4649	0.4649	0.4649	0.4649
TIME FLT LN RPR	0.2800	0.2324	0.2324	0.2324	0.2324	0.2324	0.2324	0.2324	0.2324	0.2324
PROB PART FROM PLL	0.2040	0.1693	0.1693	0.1693	0.1693	0.1693	0.1693	0.1693	0.1693	0.1693
TIME PART FROM PLL	0.4284	0.3556	0.3556	0.3556	0.3556	0.3556	0.3556	0.3556	0.3556	0.3556
PROB PART FROM ASL	0.0775	0.0644	0.0644	0.0644	0.0644	0.0644	0.0644	0.0644	0.0644	0.0644
TIME PART FROM ASL	0.1868	0.1550	0.1550	0.1550	0.1550	0.1550	0.1550	0.1550	0.1550	0.1550
PROB PART FROM THEAT	0.0133	0.0110	0.0110	0.0110	0.0110	0.0110	0.0110	0.0110	0.0110	0.0110
TIME PART FROM THEAT	1.6287	1.3520	1.3520	1.3520	1.3520	1.3520	1.3520	1.3520	1.3520	1.3520
PROB PART FROM CONUS	0.0033	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
TIME PART FROM CONUS	2.8032	2.3270	2.3270	2.3270	2.3270	2.3270	2.3270	2.3270	2.3270	2.3270
PROB CONTROL SUB	0.0018	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015
TIME CONTROL SUB	0.0057	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048
PROB 1	1.0000	0.9430	0.9430	0.9430	0.9430	0.9430	0.9430	0.9430	0.9430	0.9430
PROB 2	0.1400	0.1320	0.1320	0.1320	0.1320	0.1320	0.1320	0.1320	0.1320	0.1320
PROB 3	.0000	0.0760	0.0760	0.0760	0.0760	0.0760	0.0760	0.0760	0.0760	0.0760
PROB 4	.0000	0.0437	0.0437	0.0437	0.0437	0.0437	0.0437	0.0437	0.0437	0.0437
PROB 5	1.0000	0.8803	0.8803	0.8803	0.8803	0.8803	0.8803	0.8803	0.8803	0.8803
PROB 6	0.0960	0.0905	0.0905	0.0905	0.0905	0.0905	0.0905	0.0905	0.0905	0.0905
PROB 7	0.0185	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174
BIT APPLIES	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500

TABLE A-5 (Continued)

Depot Transit Time

EVENT/EXCURSION	PERFECT BIT	BASE	DEPOT TRANS =7	DEPOT TRANS =6	DEPOT TRANS =5	DEPOT TRANS =4	DEPOT TRANS =3	DEPOT TRANS =2	DEPOT TRANS =1	DEPOT TRANS =0
FLT LN REPAIR	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
NEED PART	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
MAINT ACTION	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
GO TO NSC	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
RETURN TO FLT LN	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
PART ON PLL	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
GO TO AMC	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
PART ON ASL	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
IN STK ASL	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500	0.8500
RTN TO ACFT	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
GO TO PLL STOCK	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
IN STK PLL	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
CONTROL SUB	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
GO TO ACFT	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
REMOVE PART	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000	0.3000
RTN TO OWN ACFT	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000	0.6000
THEATER SEARCH	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000	24.0000
PART IN THEATER	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000
PART TO AMC	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000	96.0000
REQ FM CONUS	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000	840.0000
BIT APPLIES	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500	0.9500
AVERAGE TIME 1	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094	0.6094
PROBABILITY 8	0.3000	0.2829	0.2829	0.2829	0.2829	0.2829	0.2829	0.2829	0.2829	0.2829

TABLE A-5 (Continued)

Depot Transit Time

EVENT/EXCURSION	PERFECT BIT	BASE	DEPOT TRANS =7	DEPOT TRANS =6	DEPOT TRANS =5	DEPOT TRANS =4	DEPOT TRANS =3	DEPOT TRANS =2	DEPOT TRANS =1	DEPOT TRANS =0
PROBABILITY 9	0.0510	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481	0.0481
AVERAGE TIME 2	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000	0.5000
PROB MSC W/O PART	0.1400	0.1162	0.1162	0.1162	0.1162	0.1162	0.1162	0.1162	0.1162	0.1162
TIME MSC W/O PART	0.1820	0.1511	0.1511	0.1511	0.1511	0.1511	0.1511	0.1511	0.1511	0.1511
PROOF PROB	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
FLYING HOURS	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000	480.0000
MTBEMA	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000	4.5000
ELAPSED HOURS	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000	168.0000
ACFT ASSIGNED	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000	11.0000

APPENDIX B

Figure B-1 is a flow chart of the model used to assess the impact of degraded BIT performance and to perform the sensitivity analysis.

The model begins with the necessity to perform a maintenance action. The model allows maintenance to be performed on the flight line, at the Headquarters and Service Company, or at depot. Depot maintenance assistance is only required if the BIT does not perform properly either during the initial diagnostic process or during check out after maintenance has been performed.

Line replaceable units are (1) not required, (2) obtained from the PLL, (3) obtained from the ASL, (4) obtained from other in theater stocks, (5) obtained through controlled substitution, or (6) obtained from CONUS. However, the model only examines those possibilities if the repair is being performed by user level maintenance. In each event where depot maintenance is required, the same transportation delay, labeled "depot trans" and a maintenance time labeled "depot maint" are used throughout the excursion.

For the excursions run in conjunction with this study, most of the values for the probabilities at the various decision points and for the various delays were taken from the RAM Rationale Report. For the decisions relative to BIT performance, the values used were the variable inputs to the model. The times associated with depot maintenance were developed based upon the subjective evaluation of the depot maintenance time for the AH-64 and the general disposition of units on the battlefield.

The application of the model computes the expected value of the down time for each possible maintenance path. The composite probabilities and average times shown in the diagram, are dummy operations inserted only to simplify the formulas required to compute expected value. They are shown to avoid confusion since they are listed in the tables in Appendix A.

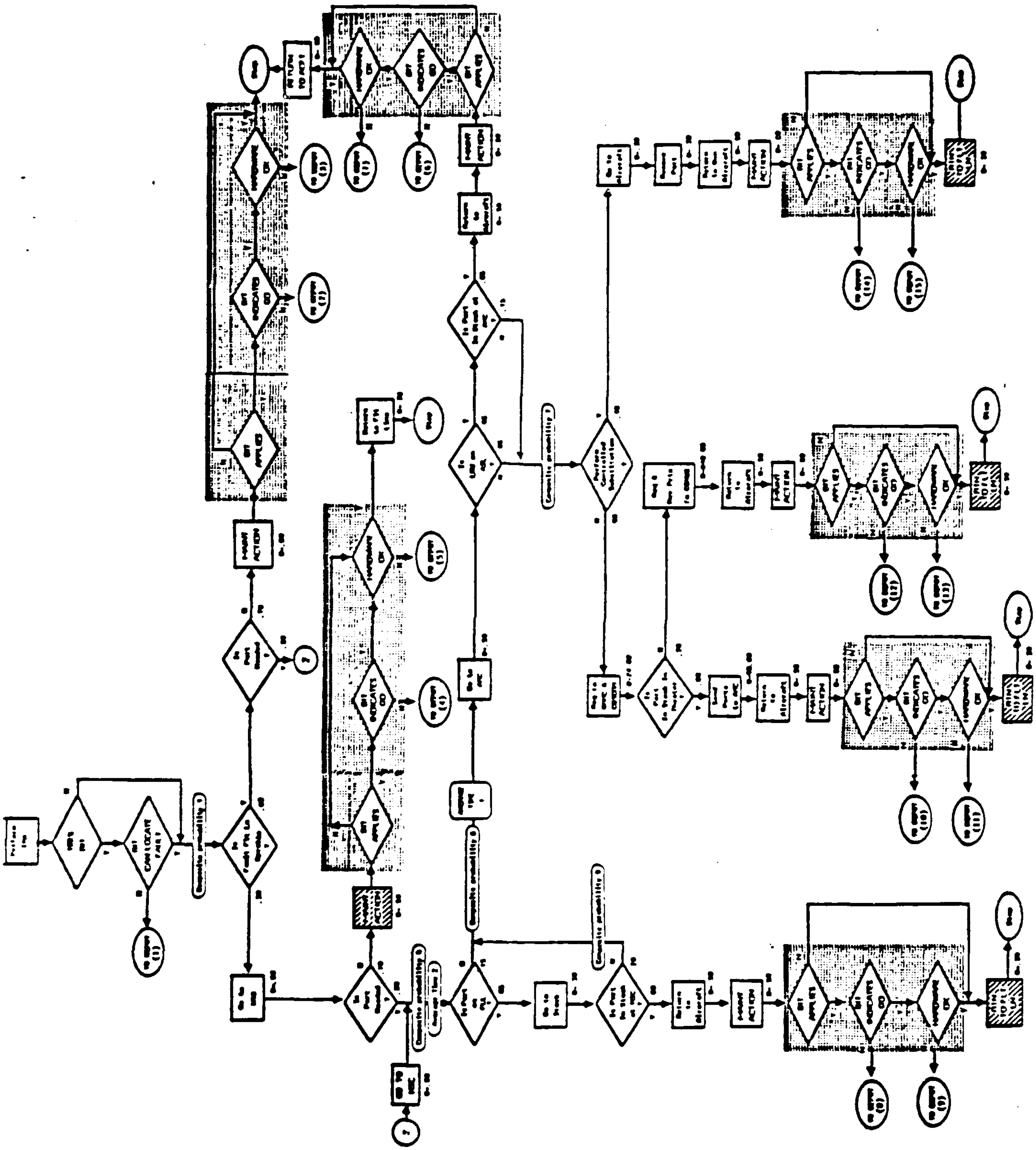

Figure B-1. Wartime ALDT with built-in test.